BLACK & VEATCH

8720 Castle Creek Parkway
Suite 210
Indianapolis, IN 46250
Tel: 317-570-8331
Fax: 317-570-8356

Black & Veatch Corporation

City of Bloomington Utilities Department
Water Supply Evaluation

B&V Project 146258.100
B&V File B
June 29, 2007

Mr. Patrick Murphy
Director of Utilities
City of Bloomington Utilities Department
501 N. Morton Street, Suite 108
Bloomington, IN 47404

Subject: Final Report – Water Supply Evaluation

Dear Patrick:

Black & Veatch is please to submit the Water Supply Evaluation Final Report. Enclosed are 20 copies of the report for your distribution and use.

This report discusses the short-term and long-term water needs for the City of Bloomington Utilities Department and how to best meet those needs with respect to the Lake Monroe water supply. In addition, the Water Supply Evaluation provides an update to the Long Range Water Capital Plan for improving the City's water treatment facilities and distribution system. The Water Supply Evaluation also provides recommendations for the basis of design, construction, project implementation and the opinion of probable construction cost for the recommended improvements.

We would like to thank you and your staff for the support in developing the report. We look forward to working with the City of Bloomington Utilities Department on future improvements to the City's water treatment facilities and distribution system. Should you have any questions, please do not hesitate to contact me.

Very truly yours,

BLACK & VEATCH CORPORATION

Donnie Ginn, P.E.
Project Manager

CITY OF BLOOMINGTON UTILITIES DEPARTMENT
WATER SUPPLY EVALUATION

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EXECUTIVE SUMMARY

A. INTRODUCTION

The purpose of the Water Supply Evaluation is to evaluate the short-term and long-term water needs for the City of Bloomington Utilities Department (CUD) and determine how to best meet those needs with respect to the Lake Monroe water supply. The Water Supply Evaluation includes a review of population projections and an evaluation of the Lake Monroe water supply and applicable treatment technologies. It also contains a review of the water system alternatives presented in the Long Range Water Capital Plan (LRWCP), including an implementation plan and opinion of probable costs. This Executive Summary provides an overview of the principal findings and recommendations included in the Water Supply Evaluation for CUD.

B. POPULATION REVIEW

Population is the most commonly used basis for estimating future water use. The Water Supply Evaluation reviewed previous population projections to assist with the determination of short-term and long-term needs. In order to predict future water demands accurately, it is necessary to determine the appropriate rate, direction, and characteristics of the area's future population changes.

Population information prepared by the U.S. Census Bureau, Indiana STATS in association with the Indiana Business Research Center (IBRC) and Black & Veatch (B&V) for the LRWCP was reviewed, compared and updated to reflect revisions since the LRWCP was completed in 2003. The U.S. Census Bureau has maintained historical population data for the City of Bloomington and Monroe County since 1940. Projections prepared by Indiana STATS have been forecasted to 2040. Additionally, the B&V projections prepared in the LRWCP were extended from 2030 through 2060 in 10-year increments. The population projections utilized for this study are presented in Table ES-1, which compares the projections for Monroe County as prepared by Indiana STATS and B&V based on the 1980-1990 annual growth rate for Monroe County of 1.0%.

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Table ES-1
Monroe County Population Projections

Year	Indiana STATS	B&V
2000	120,563	120,563
2010	132,940	133,003
2020	141,828	146,729
2030	149,228	161,871
2040	155,226	178,576
2050	NA	197,004
2060	NA	217,335

On January 10, 2003, it was announced that the Interstate 69 Corridor (I-69) would be routed through Bloomington. The estimated time to completion is anywhere from 8 to 14 years. As part of the Water Supply Evaluation, B&V evaluated the potential effect of I-69 on the geographical distribution of the population or future development in the CUD service area. The Long Range Transportation Plan (LRTP) concluded that I-69 will not significantly affect the population. Based on the population projection comparison between Indiana STATS, B&V and the 2030 LRTP, it is recommended to continue the use of the B&V projections as they are aligned with Indiana STATS and LRTP.

C. WATER REQUIREMENTS REVIEW

The projected water use for the CUD system is based on the population projections. Average day (AD), maximum day (MD), and maximum hour (MH) demands are utilized for design and operation of water treatment and distribution system facilities. A summary of AD, MD and MH water use in million gallons per day (mgd) for base year 2000 and years 2010 to 2060, in 10-year increments, is presented in Table ES-2.

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Table ES-2
Projected Water Use Requirements per B&V LRWCP Population Projections

Year	Average Day, mgd	Maximum Day, mgd	Maximum Hour, mgd
2000	13.1	20.6	24.5
2010	15.2	24.2	28.7
2020	17.2	27.7	32.9
2030	19.6	32.2	38.1
2040[1]	21.8	35.9	42.6
2050[1]	24.0	39.7	47.1
2060[1]	26.2	43.5	51.6

[1] Values for 2040, 2050 and 2060 are extrapolated from the projected values (2010, 2020 and 2030) developed for the Long Range Water Capital Plan (January 2003).

Although there are no current concerns with regards to meeting water demands, it is recommended that CUD evaluate potential water conservation programs. Long-term conservation programs can be practiced by various entities associated with water use including the end users and water suppliers. Table ES-3 lists examples of some of the common practices for water conservation by each of these entities.

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Table ES-3
Examples of Water Conservation Practices

Residential End User	Industrial End User	Agricultural End User	Water Suppliers (Utilities)
Low-flush toilets	Water reuse and recycling	Irrigation practices to distribute water more effectively	Metering
Toilet displacement devices	Cooling water recirculation	Monitoring soil and water conditions	Leak detection programs
Low-flow showerheads and faucets	Reuse of deionized water	Water reuse and recycling	Water main rehabilitation programs
Faucet aerators	Efficient landscape irrigation practices		Water reuse
Pressure reducing valves on service connection			Retrofit programs
Gray water use			Modifications to existing rate structure
Efficient landscape irrigation (xeriscape)			Public education

D. WATER SUPPLY

CUD has relied on the 24 mgd Monroe Water Treatment Plant (WTP) as the sole source of treated water since the Griffy WTP was retired from service in 1996. The Monroe WTP treats water withdrawn from Lake Monroe to meet all current regulatory standards. The processes at the Monroe WTP include rapid mixing, sedimentation, filtration and disinfection. The facility is connected to the Bloomington water distribution system by a single 36-inch transmission main that conveys treated water approximately eight miles from the plant to the City. Any interruption in service, either at the WTP, along the transmission main or with any of the critical ancillary distribution system facilities, for more than a few hours could result in a significant reduction or total suspension of water service to CUD's customers.

Water supply considerations for Bloomington were studied and reported upon in 1973, 1976, 1986, 1993, 2000 and 2003 in the LRWCP. B&V reviewed the prior water supply and capacity considerations, and completed an update with respect to current conditions and projected needs. Water supply sources that were reviewed and evaluated during the LRWCP included Lake Monroe, Lake Lemon/Bean Blossom Creek, Griffy Lake, and groundwater supply.] In addition, the yield of Lake Monroe, raw water quality characteristics, pending regulatory considerations, sedimentation, and climate change impacts were reviewed as presented in Section 4 - Water Supply. Based upon B&V's review and evaluation of the water supply, Lake Monroe has a sufficient safe yield beyond 2060 based on water demand projections. It is recommended that CUD consider discussions with Indiana Department of Natural Resources (IDNR) to secure the water supply into the future from Lake Monroe as it is a viable and reliable long-term source.

E. TREATMENT TECHNOLOGIES

Currently, the water industry is experiencing a period of rapid and unprecedented changes with regards to available treatment technologies. These changes are being driven by new regulations implemented in response to federal legislation; by the introduction of new water treatment processes, which have expanded many utilities' capabilities to meet specific treatment requirements; and by rising consumer expectations regarding the quality of their water.

Review of pending and anticipated future regulatory requirements suggests that there are several water quality/treatment-related parameters that will likely need to be addressed in the design of any future treatment expansion utilizing either the existing Lake Monroe supply or a new surface water or groundwater supply. The suggested water quality goals for the design of any future treatment expansion are summarized in Table ES-4.

Table ES-4
Suggested Water Quality Goals

Parameter	Goal
Turbidity	♦ Settled water turbidity should be less than 2 NTU ♦ Combined filter effluent turbidity should be ≤ 0.10 NTU for 95% of samples ♦ Individual filter effluent turbidity should be ≤ 0.15 NTU for 95% of samples
Disinfection Byproducts	♦ DBPs should be ≤ 75% of the MCL at any time ♦ Average DBP concentration should be ≤ 50% of MCL
Microbial Pathogens	Provide for removal/inactivation of *Cryptosporidium* oocysts
Total Organic Carbon	Maintain minimum of 35% removal
Iron	Finished water concentration ≤ 0.05 mg/L at all times
Manganese	Finished water concentration ≤ 0.02 mg/L at all times

B&V evaluated applicable technologies that were considered feasible for the design of any future treatment expansion utilizing either the existing Lake Monroe supply or a new surface water or groundwater supply. A summary of the advantages and disadvantages of the applicable technologies is presented in Section 5 - Treatment Technologies.

F. REVIEW OF WATER SYSTEM ALTERNATIVES

As presented in the LRWCP, to meet future water requirements, CUD will need to either expand the Monroe WTP (Alternative A) or construct either a new Dillman (Alternative B) or North (Alternative C) WTP. The following is a review of the improvements required for each alternative. The review is based on current water treatment technology recommendations for a new water treatment plant and expansion of the Monroe WTP as discussed in Section 5 - Treatment Technologies. Each of the alternatives discussed below would require the rehabilitation of the existing filters and filter valves at the Monroe WTP. A list of advantages and disadvantages were developed as part of the evaluation of the alternatives and are presented in Section 6 - Review of Water Supply System Alternatives.

1. Alternative A – Expand Monroe Water Treatment Plant from 24 to 36 mgd

Alternative A includes expanding the 24 mgd Monroe WTP to a capacity of 36 mgd. This alternative would require a parallel 30-inch raw water line to be installed from the intake to the plant and a parallel 36-inch finished water transmission main from the plant to Harrell Road and Moffat Lane. The proposed 36-inch finished water transmission main would connect to the existing 36-inch transmission main near the intersection of Harrell Road and Moffat Lane and the new main would continue north along Harrell Road as a 30-inch main. This alternative includes a new Southeast Pump Station and Tank located near Harrell and Rhorer Roads; a 36-inch main along Rhorer to Sare Road; and a 24-inch North branch main along Sare Road to the existing 24-inch main in Moores Pike. The 24-inch West branch main is required to reinforce the western portion of the Central Zone and will be completed by CUD as a separate project. Therefore, the West branch is not included in the costs for Alternative A. The West branch continues west along Rhorer Road, then north along South Rogers Street to West Country Club Drive, then west along Country Club Drive to connect to the two existing 24-inch mains at the intersection of Rockport and West Tapp Roads. Based on review of the water treatment technologies in Section 5 - Treatment Technologies, this option would include high rate clarification using inclined plates, followed by granular media filtration. Installation of Ultraviolet (UV) disinfection is recommended as an additional disinfection barrier. The cost for UV disinfection is shown as an alternative cost in Section 8 - Opinion of Probable Costs.

2. Option to Alternative A – Expand Monroe Water Treatment Plant from 24 to 30 mgd

Option to Alternative A involves expanding the 24 mgd Monroe WTP to a capacity of 30 mgd. Increasing the capacity from 24 to 30 mgd would allow CUD to build the facilities necessary to serve their customers through 2025. The distribution system improvements and water treatment technologies for this alternative would be the same as Alternative A. The high rate clarification basin would be sized for 12 mgd capacity to match the capacity of the existing basins. In addition, piping and electrical systems for this alternative will accommodate a future capacity of 36 mgd.

3. Alternative B – New 12 mgd Dillman Water Treatment Plant

Alternative B involves constructing a new 12 mgd membrane filtration WTP that is expandable to 24 mgd, adjacent to the Dillman Wastewater Treatment Plant (WWTP), near Dillman Road and Victor Pike. Raw water would be conveyed through a 36-inch transmission main from a new intake located near the Indiana Department of Natural Resources (IDNR) site on Lake Monroe. From the Dillman WTP's high service pumps, finished water would be conveyed through a 36-inch transmission main into two 24-inch Central service level mains at Rockport and Tapp Roads and a 16-inch main along West Country Club Drive between Rockport Road and South Old SR 37. Installation of UV disinfection at the Monroe WTP is also recommended as an additional disinfection barrier and to provide similar high quality water to CUD customers as the Dillman WTP. The cost for UV disinfection is shown as an alternative cost in the Appendix - Opinion of Probable Project Costs.

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4. Alternative C – New 12 mgd North Water Treatment Plant Using Groundwater Supply with Membrane Filtration

Alternative C involves constructing a new 12 mgd North WTP with membrane filtration that is expandable to 24 mgd, near Bottom Road and State Route 37 or adjacent to the Blucher Poole WWTP. Groundwater from a collector well, located approximately 12 miles north of Bloomington near the confluence of the White River and Bean Blossom Creek, would be conveyed through a 36-inch transmission main to the new plant. The plant would treat the water using membrane filtration for solids removal and reverse osmosis (RO) for softening. If the water supply to the North is considered to be strictly groundwater, using microfiltration/ultrafiltration (MF/UF) membranes prior to RO membranes would not be recommended from an economical standpoint; oxidation of any iron and manganese followed by conventional gravity media filters would be recommended in lieu of the MF/UF membranes. From the new North WTP, finished water would be conveyed through a 36-inch transmission main to the Central service level mains near Stonemill Road and Old State Route 37. If the North WTP is expanded to 24 mgd, then the 36-inch main should be extended as a 24-inch main along Walnut Street to the existing 24-inch main on 20th Street. Installation of UV disinfection at the Monroe WTP is also recommended as an additional disinfection barrier and to provide similar high quality water to CUD customers as the North Plant. The cost for UV disinfection is shown as an alternative cost in the Appendix - Opinion of Probable Project Costs.

5. Option to Alternative C – New 12 mgd North Water Treatment Plant Using Groundwater Supply with Gravity Media Filtration

Option to Alternative C involves constructing a new 12 mgd North WTP with gravity media filtration that is expandable to 24 mgd, near Bottom Road and State Route 37 or adjacent to the Blucher Poole WWTP. Groundwater from a collector well, located approximately 12 miles north of Bloomington near the confluence of the White River and Bean Blossom Creek, would be conveyed through a 36-inch transmission main to the new plant. The plant would treat the water using gravity media filtration for solids removal and reverse osmosis (RO) for softening. From the new North WTP, finished water would be conveyed through a 36-inch transmission main to the Central service level mains near Stonemill Road and Old State Route 37. If the North WTP is expanded to 24 mgd, then the 36-inch main should be extended as a 24-inch main along Walnut Street to the existing 24-inch main on 20th Street. Installation of UV disinfection at the Monroe WTP is also recommended as an additional disinfection barrier and to provide similar high quality water to CUD customers as the North Plant. The cost for UV disinfection is shown as an alternative cost in the Appendix - Opinion of Probable Project Costs.

G. RECOMMENDED ALTERNATIVE

Based on the review of the alternatives, it is recommended that CUD proceed with Alternative A and the option to expand the existing Monroe WTP from 24 to 30 mgd. This alternative was selected based on several factors including comparison of the capital and operation and maintenance costs and advantages and disadvantages. Alternative A has the lowest capital and O&M costs of the alternatives evaluated.

H. IMPLEMENTATION PLAN

An implementation plan was developed for the option to Alternative A - Expand Monroe WTP from 24 to 30 mgd. It is recommended that the construction of the facilities and transmission mains associated with expansion of the Monroe WTP be completed in three separate phases as follows:

- Phase 1 – Monroe WTP Filter Rehabilitation (Project Underway)
- Phase 2 – Southeast Water System Improvements
- Phase 3 – Monroe WTP Expansion

Phase 1 is currently under design and construction is expected to begin in mid-2007. Phase 2 includes approximately 44,000 linear feet (LF) of 24 to 36 inch transmission mains, a 12 mgd pump station expandable to 24 mgd, and a 2.0 million gallon storage tank. Phase 3 includes expansion of the Monroe WTP and Intake Facility to increase the capacity of the plant.

The schedule developed allows for completion of Phase 2, Southeast Water System Improvements, in 2010 and will provide adequate storage and pumping to meet expected demands. The Phase 3 improvements for the Monroe WTP Expansion from 24 to 30 mgd are scheduled for completion in 2011.

I. OPINION OF PROBABLE COSTS

The opinion of probable project costs were developed for the option to Alternative A - Expand Monroe WTP from 24 to 30 mgd. All of the probable construction and project costs presented herein reflect price levels for January 2007, and include an allowance of 20 percent for contingencies. An allowance has been included for engineering, construction administration, resident engineering, SCADA configuration, surveying, and subsurface investigations. Land and easement acquisition has been included as a separate cost. These costs do not include legal, financial consulting, bond issuance, CUD staff salaries or expenses related to the project or unusual construction conditions. The opinion of probable cost for the option to Alternative A with expansion of the plant from 24 to 30 mgd using conventional filtration is presented in Table ES-5. Installation of UV disinfection is recommended as an additional disinfection barrier. The cost for UV disinfection is shown as an alternative cost. Details of the opinion of probable project cost are presented in Section 8 - Opinion of Probable Costs.

Table ES-5 Opinion of Probable Costs[1, 2]	
Phase	**Cost**
Phase 1 - Monroe WTP Filter Rehabilitation ($1,900,000)	Funded
Phase 2 - Southeast Water System Improvements	$20,500,000
Phase 3 - Monroe WTP Expansion	$18,000,000
Total Probable Cost (Phases 2 and 3)	**$38,500,000**
UV Disinfection Alternative	$3,600,000

[1] All costs are based on January 2007 price levels.
[2] Phase 1 costs for the Monroe WTP Filter Rehabilitation are currently budgeted in fiscal year 2007, and are not included in the Total Project Probable Cost.

J. CONCLUSIONS AND RECOMMENDATIONS

Based on the review of the alternatives, it is recommended that CUD proceed with Alternative A and the option to expand the existing Monroe WTP from 24 to 30 mgd. This alternative includes expanding the capacity of the Monroe WTP using conventional filtration; constructing new parallel raw and finished water mains to convey the additional flow; and constructing the Southeast Water System Improvements that will convey the additional treated water from the South service level to the Central service level. Installation of UV disinfection is recommended as an additional disinfection barrier. The cost for UV disinfection is shown as an alternative cost in Section 8 - Opinion of Probable Costs.

This alternative was selected based on several factors including comparison of the capital and operation and maintenance costs and advantages and disadvantages. Alternative A has the lowest capital and operation and maintenance costs of the alternatives evaluated. Expanding the Monroe WTP does not provide the same level of reliability as having a second water supply or treatment plant, although with the appropriate measures a reasonable level of reliability can be achieved. The second 36-inch finished water transmission main and Southeast Pump Station address a concern identified in the 2002 Vulnerability Assessment. Additionally, the existing 36-inch raw and finished water transmission mains were inspected in 2005. Based on the examinations and testing, the pipelines were determined to be in overall excellent condition.

1. INTRODUCTION

A. PURPOSE AND SCOPE

The purpose of the Water Supply Evaluation is to evaluate the short-term and long-term water needs for the City of Bloomington Utilities Department (CUD) and to determine how to best meet those needs with respect to the Monroe Lake water supply. This report has been prepared to provide CUD with information on the long-term viability and reliability of Lake Monroe as a water source. In addition, this report provides an update to the Long Range Water Capital Plan (LRWCP) for improving and expanding CUD's water treatment facilities and distribution system. The Water Supply Evaluation provides recommendations for the basis of design, construction, and implementation of the recommended improvements. The recommendations in this Water Supply Evaluation do not promote or encourage growth, but are developed to ensure that CUD can provide an adequate supply of water and keep pace with projected future growth in the City of Bloomington and Monroe County.

The principal elements in this study include the following:

- An update to the Long Range Water Control Plan (LRWCP) completed in 2003.
- An updated projection of future population and a water requirements review based on the LRWCP.
- A review of Lake Monroe as a water supply source and a review of the safe yield based on existing conditions and future needs.
- An update of the available treatment technologies for the Lake Monroe water supply.
- An updated review of the recommended water system improvement alternative.
- An implementation plan and opinion of probable project costs for the recommended water system improvement alternative.

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B. ABBREVIATIONS

Abbreviations used in this report are as follows:

AD	Average Day
AWWA	American Water Works Association
B&V	Black & Veatch
BOM	Biodegradable Organic Matter
cfs	Cubic Feet per Second
ClO2	Chlorine Dioxide
CT	Contact Time
CUD	City of Bloomington Utilities Department
DAF	Dissolved Air Flotation
DBP	Disinfection Byproducts
DBPR	Disinfectants and Disinfection Byproducts Rule
EBCT	Empty Bed Contact Time
ft	Feet
GAC	Granular Activated Carbon
gpcd	Gallons per Capita per Day
gpm	Gallons per Minute
gpd	Gallons per Day
HAA5	Haloacetic Acid (5 specific)
I-69	Interstate 69 Corridor
IBRC	Indiana Business Research Center
ICI	Industrial/Commercial/Institutional
ICR	Information Collection Rule
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
IDSE	Initial Distribution System Evaluation
in	Inch
LCP	Lined Cylinder Pipe
LF	Linear Feet

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LRTP	Long Range Transportation Plan
LRWCP	Long Range Water Capital Plan
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	Maximum Contaminant Level
MD	Maximum Day
MF	Microfiltration
mgd	Million Gallons per Day
mg/l	Milligrams per Liter
MH	Maximum Hour
MIB	Methylisoborneol
mm	Millimeters
MPO	Metropolitan Planning Organization
msl	Mean Sea Level
NDMA	N-nitrosodimethylamine
NTU	Nephelometric Turbidity Units
O&M	Operations and Maintenance
PAC	Powdered Activated Carbon
psi	Pounds per Square Inch
RO	Reverse Osmosis
SDWA	Safe Drinking Water Act
SMP	Standard Monitoring Program
SSS	System Specific Study
TOC	Total Organic Carbon
TTHM	Total Trihalomethane
UF	Ultrafiltration
ug	Microgram
U.S.	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

1. INTRODUCTION

C. BACKGROUND MATERIAL

Background reference material for this Water Supply Evaluation includes the following:

- 1964, Report on Water Works Improvements for Bloomington, Indiana, Black & Veatch.
- 1973, Long Range Plan Water Supply and Distribution Facilities for Bloomington, Indiana, Black & Veatch.
- 1976, Review of Monroe Reservoir Water Purchase Agreement Report on Phase 1 Studies, Franklin Consultants Inc., and McCullough & Associates.
- 1986, Water Supply Treatment and Distribution for Bloomington, Indiana, Black & Veatch.
- 1993, City of Bloomington Utilities Water Facilities Capital Improvement Program Assessment, Black & Veatch.
- 1999, City of Bloomington Utilities Water System Improvements, Drinking & Water State Revolving Fund Preliminary Engineering Report, Black & Veatch.
- 2000, New Water Treatment Plant Siting Study, Black & Veatch.
- 2000 Census, U.S. Census Bureau.
- 2002, City of Bloomington, Growth Policies Plan, 4th Draft.
- 2003, City of Bloomington Utilities, Long Range Water Capital Plan, Black & Veatch.
- 2005, City of Bloomington Utilities, 36” LCP Lake Monroe Transmission Main Condition Assessment Project Final Report, Price Brothers Company.
- 2006, 2030 Long Range Transportation Plan, Bloomington/Monroe County Metropolitan Planning Organization.

1. INTRODUCTION

D. HISTORY OF BLOOMINGTON'S WATER SUPPLY AND TREATMENT

Throughout its history, Bloomington has experienced water shortages caused by weather conditions, lack of natural water supplies, and water storage imbalances. However, CUD has an excellent record of achievements in providing safe water to its customers. As in the past, the importance of making today's timely decisions will only be verified by the future. This Water Supply Evaluation will provide CUD with options to maintain a safe and reliable drinking water well into the future. Future water supply, usage, and development are, and should be, a concern to every water utility. This concern applies to both quantity and quality. As Bloomington has experienced, without properly developing and managing the water supply and treatment facilities, shortages can and will occur.

A timeline of Bloomington's most significant water achievements follows:

- Monroe County founded
- 1860 Cisterns built on Courthouse Square and contaminated by human and animal wastes
- 1885 Courthouse well drilled 2,670 feet – dry
- 1891 Water Franchise established
- 1892 Upper Twin Lake built
- 1893 Twin Lakes WTP constructed
- 1894 Twin Lakes WTP placed on line
- 1898 Plant sold to City
- 1899 Plant shut down due to lack of water
- 1902 Plant shut down due to lack of water
- 1905 Lower Twin Lake built
- 1909 Weimer (Wapehani) Lake built
- 1911 University Lake built
- 1915 Leonard Springs Lake built
- 1922 Plant shut down three days per week due to lack of water
- 1924 Private water company formed

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- 1925 Griffy Lake built and Griffy WTP begins operation
- 1939 City buys back water company
- 1953 Lake Lemon built
- 1954 Griffy WTP expanded
- 1965 Lake Monroe built
- 1967 Monroe WTP placed on line
- 1990 Monroe WTP expanded
- 1996 Griffy WTP retired
- 1997 West and Southwest Water System Improvements
- 2000 New WTP Siting Study
- 2003 Long Range Water Capital Plan
- 2006 Monroe WTP Improvements

2. POPULATION REVIEW

Population is the most commonly used basis for estimating future water use. The Water Supply Evaluation reviewed previous population projections to assist with the determination of short-term and long-term needs. In order to predict future water demands accurately, it is necessary to determine the appropriate rate, direction, and characteristics of the area's future population changes.

A. CURRENT AND PROJECTED FUTURE POPULATION

Population information prepared by the U.S. Census Bureau, Indiana Business Research Center (IBRC) and Black & Veatch (B&V) for the Long Range Water Capital Plan (LRWCP) was reviewed, compared and updated to reflect revisions since the LRWCP was prepared. The U.S. Census Bureau maintains historical population data for the City of Bloomington and Monroe County, since 1940. Projections prepared by Indiana STATS, in association with IBRC, have been forecasted to 2040. Additionally, the B&V projections prepared in the LRWCP were extended from 2030 through 2060 at 10-year increments.

The population projections in the LRWCP were determined using current and projected population figures. Three sets of population projections were evaluated. The first set was based on the assumption that the 1980-1990 growth rate of 16.5% (or 1.6% per year) for Bloomington and 10.3% (or 1.0% per year) for Monroe County occur in the future. The second set was based on the assumption that the 1990-2000 growth rate of 14.3% (or 1.4% per year) for Bloomington and 10.6% (or 1.0% per year) for Monroe County occur in the future. The final set was based on a linear regression of the Census population from 1940 through 2000. The historical and projected populations for the City of Bloomington and Monroe County are shown in Table 2-1 on the following page.

2. POPULATION REVIEW

Table 2-1
Historical and Projected Population

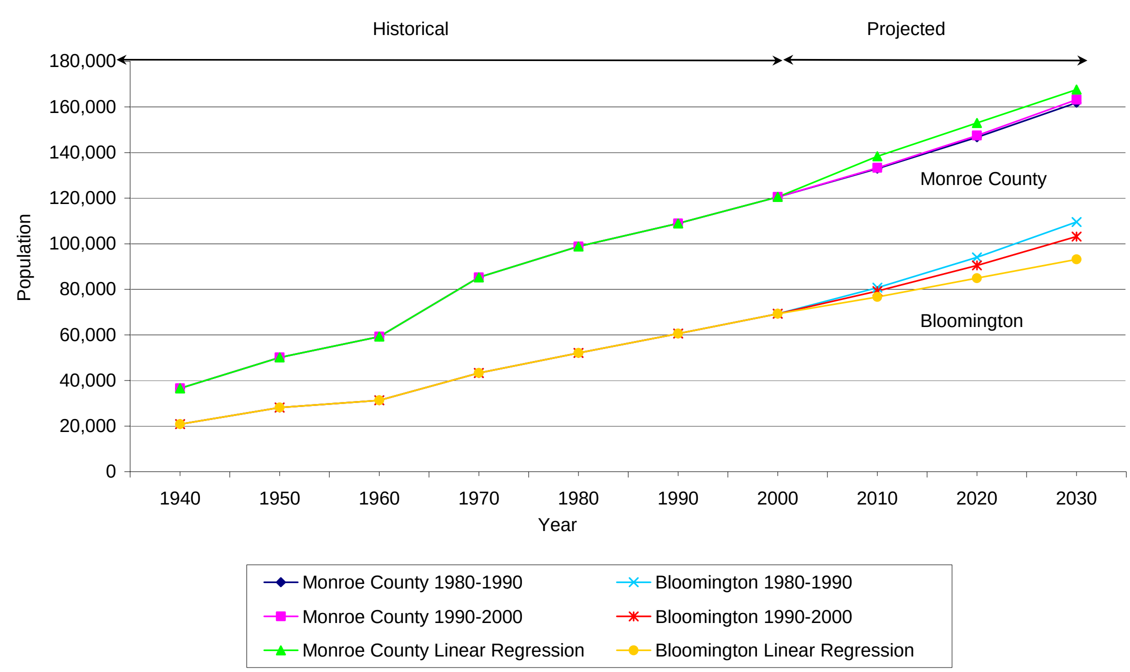
Year	Bloomington (Historical Population)		Monroe County (Historical Population Including Bloomington)	
	Population	Change	Population	Change
1940	20,870	NA	36,534	NA
1950	28,163	7,293	50,080	13,546
1960	31,357	3,194	59,225	9,145
1970	43,262	11,905	85,221	25,996
1980	52,044	8,782	98,785	13,564
1990	60,633	8,589	108,978	10,193
2000	69,291	8,658	120,563	11,585
Projected Populations using 1980-1990 Growth Rate[a]				
2005	75,008	5,716	126,783	6,220
2010	80,724	5,717	133,003	6,220
2020	94,043	13,319	146,729	13,726
2030	109,560	15,517	161,871	15,142
Projected Populations using 1990-2000 Growth Rate[b]				
2005	73,620	4,329	126,970	6,407
2010	79,185	5,565	133,378	6,408
2020	90,492	11,307	147,556	14,178
2030	103,160	12,668	163,241	15,685
Projected Populations using Linear Regression[c]				
2005	72,521	3,230	131,092	10,529
2010	76,644	4,123	138,404	7,312
2020	84,890	8,246	153,027	14,623
2030	93,136	8,246	167,650	14,623

a. Bloomington growth rate of 1.6% per year; Monroe County growth rate of 1.0% per year
b. Bloomington growth rate of 1.4% per year; Monroe County growth rate of 1.0% per year
c. Bloomington: Y=8246X+10676, R^2 = 0.9883; Monroe County: Y=14623X+21420, R^2 = 0.9845

2. POPULATION REVIEW

Figure 2-1 shows the historical and projected populations based on the 1980-1990 growth rate, the 1990-2000 growth rate, and linear regression for the City of Bloomington and Monroe County.

Figure 2-1
Historical and Projected Population



The population projections illustrated in Figure 2-1 indicate little difference between the 1980-1990 and the 1990-2000 growth rates for Bloomington and Monroe County. Although growth is expected to continue steadily for both Bloomington and Monroe County, the County will probably grow at a lower rate than the City assuming annexation and student population continues at an increased rate. The 1980-1990 growth rate produces slightly more conservative results for the City and was selected for population projections in the LRWCP.

2. POPULATION REVIEW

The U.S. Census Bureau has not prepared population projections for Monroe County beyond 2005. Therefore, Table 2-2 and Figure 2-2 compare the projections for Monroe County as prepared by Indiana STATS and B&V based on the 1980-1990 annual growth rate of 1.0% for Monroe County. Projections prepared by Indiana STATS, in association with IBRC, have been forecasted to 2040. Additionally, the B&V projections prepared in the LRWCP were extended from 2030 through 2060 at 10-year increments.

Table 2-2
Monroe County Population Projections[1]

Year	Indiana STATS	B&V
2000	120,563	120,563
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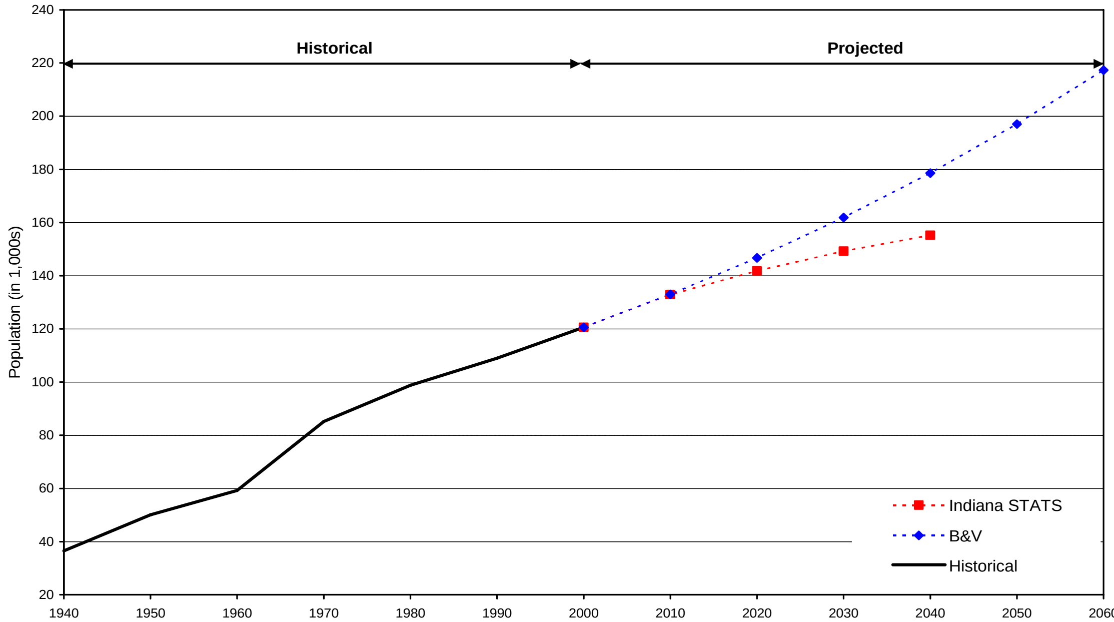
2020	141,828	146,729
2030	149,228	161,871
2040	155,226	178,576
2050	NA	197,004
2060	NA	217,335

[1] The B&V population projections for year 2050 and 2060 were extrapolated based on Indiana STATS data.

As previously noted, Figure 2-2 graphically compares the population projections prepared for Monroe County. The B&V projections are based on a 1.0% growth rate per year. Therefore, as the population increases the amount of annual growth also increases. For example, a growth rate of 1.0% for a current population of 100,000 calculates to an annual growth of 10,000. For the next year the 1.0% growth rate would be based on the population of 110,000 and would equate to a annual growth of 11,000. Although, the percent of growth is consistent over the years, the amount of growth increases.

2. POPULATION REVIEW

Figure 2-2
Monroe County Population Projections



B. INTERSTATE 69 CONSTRUCTION

On January 10, 2003, Governor O'Bannon and State Transportation Commissioner Nicol announced that the Interstate 69 Corridor (I-69) would be routed through Bloomington. They estimated the time to completion being anywhere from eight to fourteen years. It is anticipated that the location of I-69 will closely follow the existing route of State Route 37 through Monroe County.

The *2030 Long Range Transportation Plan* (LRTP) as prepared by the Metropolitan Planning Organization (MPO) Staff of the City of Bloomington Planning Department and adopted by the MPO Policy Committee on March 31, 2006, addresses the anticipated impacts of the construction of I-69. Per the LRTP, the socioeconomic impacts will be minimal while the increase in trip-making activities will be significant. The following highlights the increase in projections associated with the construction of I-69 as listed in the LRTP:

- Population – 751
- Households – 331
- Retail Employment – 171
- Total Employment – 586

The LRTP also provided Monroe County population projections for 2030 with and without I-69 to indicate the potential impact. Table 2-3 compares the 2030 population projections as developed by B&V in the LRWCP, Indiana STATS and the LRTP.

Table 2-3
2030 Monroe County Population Projections

Projection	Population
B&V - LRWCP	161,871
Indiana STATS	148,228
2000 Census and TAZ[1] I-69 Corridor Model (without I-69)[2]	159,271
2000 Census and TAZ[1] I-69 Corridor Model (with I-69)[2]	160,022

1 TAZ = Traffic Analysis Zone.
2 From 2030 Long Range Transportation Plan; source listed as “BLA Technical Memorandum 8/19/2005”.

Based on the population projection comparison between Indiana STATS, B&V and the 2030 LRTP, it is recommended to continue the use of the B&V projections as the projections are aligned with Indiana STATS and LRTP.

3. WATER REQUIREMENTS REVIEW

A water utility supplies water to meet its user's demands at flow rates that fluctuate yearly, monthly, daily and hourly. Water demands are typically higher during dry years and in hot months. The most significant demands in the design and operations of a water system are the annual Average Day (AD), the Maximum Day (MD) and the Maximum Hour (MH).

AD demand is defined as the total annual water pumped to distribution divided by the number of days in the year. The AD demand is utilized in estimating future AD, future MD, and future MH demands. The AD demand is used to determine the required yield of water supply sources and used indirectly in determining estimated future revenues and operating costs.

MD demand is defined as the largest quantity of water pumped to distribution on any one day during the year. The MD demand is utilized in sizing most water supply and treatment facilities.

MH demand is defined as the largest quantity of water pumped to distribution, adjusted for any inflow and outflow from system storage, in any one-hour period during the year. Since minimum distribution system pressures are commonly experienced during the MH, the sizes and locations of distribution facilities are determined considering maximum hour conditions. MH demands are met using strategically located system storage. The use of system storage minimizes the required capacity of the treatment facilities, the water transmission mains, and the pumping facilities. It also results in a more uniform and economical operation of the water system as a whole.

A. WATER USE PROJECTIONS

Per the Long Range Water Capital Plan (LRWCP), the water use projections were developed for the total system for the base year (year 2000) and years 2010, 2020 and 2030. For the Water Supply Evaluation, these projections have been extrapolated to 2040, 2050 and 2060.

3. WATER REQUIREMENTS REVIEW

Population projections and historical water use are the most common means for projecting water demands. In the LRWCP, the water use projections were determined to 2030 in 10-year increments. Based on the LRWCP and population projections discussed in Section 2 – Population Review, the water use projections have been extrapolated to 2060 in 10-year increments. The analysis of the water requirements utilizing the population projections results in a projection of the residential water use requirements for the City of Bloomington Utilities Department (CUD). Based on the analysis performed during the LRWCP, a demand of 85 gallons per capita per day (gpcd) was utilized to calculate the residential water use for years 2040, 2050 and 2060.

As discussed in Section 2 - Population Review, the Indiana STATS population projections have been forecasted out to 2040 and the B&V LRWCP projections have been extrapolated out to 2060. Table 3-1 compares the effects on residential water use requirements based on the various sets of population projections. Table 3-1 indicates the amount of forecasted water demand differing between the two sets of projections, Indiana STATS and B&V's LRWCP. This table compares the differences in residential water use for AD and MD conditions.

Table 3-1
Residential Water Use Projection Comparison

Year	Population Projections		Water Use Difference, mgd	
	Indiana STATS	B&V LRWCP	Average Day[1]	Maximum Day[2]
2000	120,563	120,563	0.0	0.0
2010	132,940	133,003	0.005	0.008
2020	141,828	146,729	0.4	0.6
2030	149,228	161,871	1.1	1.8
2040	155,226	178,576	2.0	3.2

[1] Average Day water use difference is calculated with a per capita use of 85 gallons per day (gpd).
[2] Maximum Day water use difference is calculated based on the MD/AD peaking factor 1.6 as developed in the LRWCP.

3. WATER REQUIREMENTS REVIEW

Additionally, Table 3-2 compares the residential water use difference in million gallons per day (mgd) among the population projections for year 2030 as described in Section 2 - Population Review. The population projections prepared for the *2030 Long Range Transportation Plan* (LRTP) have been included to indicate the effects on the residential water use with or without the construction of Interstate 69 Corridor (I-69).

Table 3-2
2030 Residential Water Use Projection Comparison

Population Projection	2030 Population	Water Use Difference, mgd	
		Average Day[1]	Maximum Day[2]
B&V LRWCP	161,871	NA	NA
Indiana STATS	149,228	1.1	1.8
2000 Census and TAZ 1-69 Corridor Model (without I-69)[3]	159,271	0.2	0.3
2000 Census and TAZ I-69 Corridor Model (with I-69)[3]	160,022	0.2	0.3

[1] Average Day water use difference is calculated with a per capita use of 85 gallons per day (gpd).
[2] Maximum Day water use difference is calculated based on the MD/AD peaking factor 1.6 as developed in the LRWCP.
[3] From *2030 Long Range Transportation Plan (adopted March 31, 2006)*; source listed as "BLA Technical Memorandum 8/19/2005".

Based on the recommendation regarding the population projections in Section 2 - Population Review and the minimal effect on residential water use projections, the water use projections developed by B&V for the LRWCP have been utilized to project water use requirements for years 2040, 2050 and 2060. Table 3-3 and Figure 3-1 list the projected water use requirements for CUD. These water use projections include residential, wholesale, industrial-commercial-institutional (ICI), Indiana University and unaccounted-for water demands. The historical demands for years 2001-2006 have been included in the evaluation. The figure indicates the projected timing of treatment capacity expansion in 6 mgd increments.

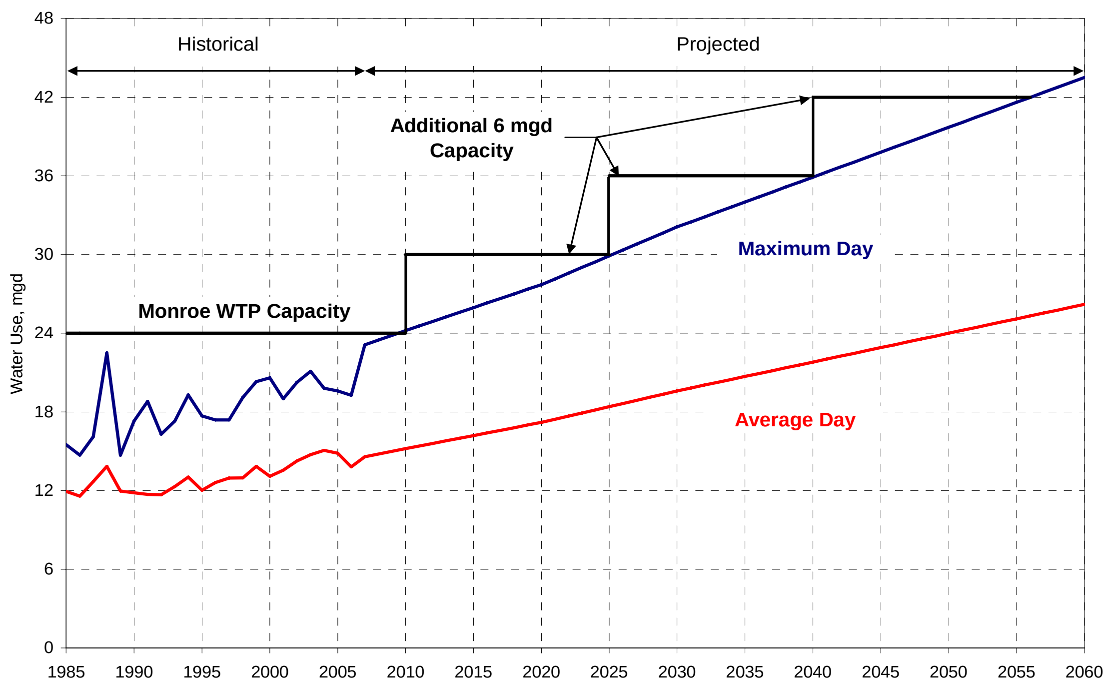
3. WATER REQUIREMENTS REVIEW

Table 3-3
Projected Water Use Requirements per B&V LRWCP Population Projections

Year	Average Day, mgd	Maximum Day, mgd	Maximum Hour, mgd
2000	13.1	20.6	24.5
2010	15.2	24.2	28.7
2020	17.2	27.7	32.9
2030	19.6	32.2	38.1
2040[1]	21.8	35.9	42.6
2050[1]	24.0	39.7	47.1
2060[1]	26.2	43.5	51.6

[1] Values for 2040, 2050 and 2060 are extrapolated from the projected values (2010, 2020 and 2030) developed with the Long Range Water Capital Plan (January 2003).

Figure 3-1
Historical and Projection Water Use Requirements



3. WATER REQUIREMENTS REVIEW

For the LRWCP, historical water use and population projections were used to estimate the average water use on a per capita basis for residential customers for the base year 2000 and years 2010, 2020 and 2030. The AD residential water use was determined by multiplying the per capita water use by the population. The AD ICI, Indiana University, wholesale, and unaccounted-for water use was estimated on a proportional basis. Per the LRWCP, the design criteria used for calculating the AD water requirements are summarized in Table 3-4.

Table 3-4
Design Criteria for Average Day Water Use Calculations

Design Criteria	2000	2010	2020	2030
Population[a]	53,154	64,187	77,506	93,023
Base Residential Use[b]	85 gpcd	85 gpcd	85 gpcd	85 gpcd
Residential/ICI Ratio (%)	38/62	40/60	42/58	44/56
Unaccounted - for (%)[c]	10	10	10	10
MD/AD Ratio	1.60	1.60	1.60	1.60
MH/AD Ratio	1.90	1.90	1.90	1.90

a. The population shown is the residential population less IU on-campus housing occupants.
b. The base residential use was determined by dividing the total residential water use of 4.5 mgd by 53,154 people (year 2000 population of 69,291 less IU on-campus housing population of 16,137).
c. For design, it is typical to allow 10% for the unaccounted-for water. Even though CUD averages 6.5% unaccounted-for water, 10% was used for design calculations.

3. WATER REQUIREMENTS REVIEW

Per the LRWCP, the AD water use by class is summarized in Table 3-5.

Table 3-5
Base Year and Projected Average Day Water Use by Class

User Class	2000		2010		2020		2030	
	mgd	%	mgd	%	mgd	%	mgd	%
Residential	4.5	34	5.5	36	6.6	38	7.9	40
ICI	2.7	20	3.5	22	4.0	23	4.7	24
IU	1.8	14	1.8	12	1.8	10	1.8	9
Wholesale	2.9	22	3.0	20	3.2	19	3.4	17
Subtotal	**11.9**	**90**	**13.8**	**90**	**15.6**	**90**	**17.8**	**90**
Unaccounted-for	1.2	10	1.4	10	1.6	10	1.8	10
Total	**13.1**	**100**	**15.2**	**100**	**17.2**	**100**	**19.6**	**100**

B. LARGE INDUSTRIAL USER

As previously discussed for the projected water use requirements, the projections incorporate increases in the ICI demand over the study period. In addition, B&V reviewed the impact that a large industrial user would have on CUD's ability to meet system demands. The evaluation utilized a water demand estimated at 1.0 mgd for a large industrial user. It was determined that an industrial user of this size would not have a significant impact on the distribution system's water demand. The addition of a large industrial user would require additional analysis regarding localized distribution system improvements as well as a thorough review of the timing and coordination of water capacity expansion efforts.

3. WATER REQUIREMENTS REVIEW

C. CONSERVATION PRACTICES

Although there are no current concerns with regards to meeting water demands, it is recommended that CUD evaluate potential water conservation programs. Per the American Water Works Association (AWWA) Manual of Water Supply Practices *Water Conservation Programs - A Planning Manual*, "water restrictions can be a useful emergency tool for drought management or service disruptions, [while] water conservation programs emphasize lasting day-to-day improvements in water use efficiency." Long-term conservation programs can be practiced by various entities associated with water use including the end users (residential, industrial and agricultural) and water suppliers (utilities). Table 3-6 lists some of the common practices for water conservation by each of these entities.

Table 3-6
Examples of Water Conservation Practices

Residential End User	Industrial End User	Agricultural End User	Water Suppliers (Utilities)
Low-flush toilets	Water reuse and recycling	Irrigation practices to distribute water more effectively	Metering
Toilet displacement devices	Cooling water recirculation	Monitoring soil and water conditions	Leak detection programs
Low-flow showerheads and faucets	Reuse of deionized water	Water reuse and recycling	Water main rehabilitation programs
Faucet aerators	Efficient landscape irrigation practices		Water reuse
Pressure reducing valves on service connection			Retrofit programs
Gray water use			Modifications to existing rate structure
Efficient landscape irrigation (xeriscape)			Public education

3. WATER REQUIREMENTS REVIEW

In order to develop a cost-effective water conservation program, the United States Environmental Protection Agency (USEPA) and AWWA recommend that the following activities be analyzed:

- Review detailed demand forecast
- Review existing water system profile and descriptions of planned facilities
- Evaluate the effectiveness of existing conservation measures
- Define conservation potential
- Identify conservation measures
- Determine feasible measures
- Perform benefit-cost evaluations
- Select and package conservation measures
- Combine overall estimated savings
- Optimize demand forecasts

D. DISTRIBUTION SYSTEM STORAGE IMPACTS

During short-term maximum water use conditions, it may be possible to utilize additional storage in the distribution system. The implementation of additional storage within the distribution system should be carefully analyzed with distribution system operations and is not recommended for long periods of maximum water use. The use of additional storage may lead to water quality concerns within the distribution system under maximum and normal operating conditions. Additionally, the ability to replenish the distribution system storage would be limited by the existing treatment and pumping capacity and may not be available for effective use during long periods of maximum water use.

4. WATER SUPPLY

Water supply considerations for the City of Bloomington Utilities Department (CUD) were studied and reported on in 1973, 1976, 1986, 1993, 2000 and 2003 in the Long Range Water Capital Plan (LRWCP). The following discussion summarizes the prior source and capacity considerations and provides an update with respect to current conditions and projected needs.

A. SOURCES OF SUPPLY

The current source of supply, Lake Monroe, and alternative sources including Lake Lemon/Bean Blossom Creek, Griffy Lake and a groundwater supply were evaluated as part of the LRWCP. However, the alternative sources are no longer being considered due to higher costs associated with capital improvement projects, water quality concerns, and concerns on sufficient yields from these sources.

1. Lake Monroe

Lake Monroe is located approximately seven miles southeast of Bloomington and has been in operation since 1966 when it was constructed by the U.S. Army Corps of Engineers (USACE). The water supply is managed by the Indiana Department of Natural Resources (IDNR). The lake is owned by the USACE, and is used for water supply, flood control and recreation. Between the silt pool elevation of 515 feet (ft) mean sea level (msl) and the flood control pool elevation of 538 ft msl, the reservoir will provide a total storage capacity of 159,900 acre-feet. The lake has a drainage area of 432 square miles, a spillway elevation of 556.0 ft, and a maximum water elevation of 556.2 ft msl recorded on May 15, 2002. CUD purchases raw water under an existing purchase agreement with IDNR for the Monroe Water Treatment Plant (WTP). The present cost to purchase raw water from IDNR is $33.00 per million gallon. The purchase agreement allows for CUD to purchase water up to a limit of an annual average daily withdrawal of 24 million gallons per day (mgd). This agreement between CUD and IDNR was renewed in January 2005.

4. WATER SUPPLY

Lake Monroe

B. YIELD OF LAKE MONROE

The yield capability of Lake Monroe was studied in 1964 for the IDNR and the City of Bloomington. The study was based upon 26 years of stream flow records, including the severe drought years of 1930-31, 1940-41, and 1953-54. The study assumed continuous releases of 50 cubic feet per second (cfs) to maintain flow in Salt Creek. Other releases were made as required to maintain 500 cfs in East Fork of White River at Shoals, and a stipulated minimum flow of 1400 cfs from April to September 15 and 1000 cfs during the remainder of the year to White River at Petersburg. The releases to supplement flow in East Fork of White River at Shoals and White River at Petersburg are not constant releases from the reservoir. It was determined, using these releases, that the maximum drop in lake level was slightly more than 12 ft and that Lake Monroe, from the top of its conservation pool at elevation 538.0 to elevation 525.75, could safely provide a uniform flow of 47 mgd for one year without any runoff being re-supplied to the lake. The remaining volume in the conservation pool was more than 53,000 acre-feet. The firm yield of Lake Monroe was conservatively estimated to be 50 percent more than the 47 mgd, or approximately 70 mgd.

4. WATER SUPPLY

Another study, completed in 1976 titled "Review of Monroe Reservoir Water Purchase Agreement" by Franklin Consultants, Inc. and McCullough & Associates, stated that the firm yield of Lake Monroe, based on the assumption the reservoir is used only for direct withdrawal for water supply, was approximately 122 mgd. This study allocated 25 percent (30 mgd) for direct withdrawal by CUD and 75 percent (92+/- mgd) for downstream uses. In addition, the report considered a release of 50 cfs, or 32.3 mgd, as a continuous release to Salt Creek. However, there appears to be some discrepancies in this report as the stated yield of 122 mgd was based only on direct withdrawals which was then further separated into direct withdrawals (30 mgd) and downstream uses (92 mgd). An appendix in the Franklin Report includes a study performed by the Indiana Flood and Control Water Resources Commission which indicates that the 122 mgd firm yield was estimated for the purpose of arriving at a unit cost figure which is relatively comparable to other water supply reservoirs. Hence, it does not appear that this report is a regulatory document, but was used as an example and for a cost comparison.

Based on our review of available records and discussions with IDNR and the USACE, the stipulated minimum outflow from the reservoir is 50 cfs. A cursory review of outflow data since 1986 indicates that the minimum release of 50 cfs has generally been maintained. However, additional releases are often made to maintain the elevations in the reservoir to not overflow the spillway or as requested by the State of Indiana to release additional flow. The maximum release on record since 1986 occurred in May 2002 and was recorded as 2,927 cfs.

The 1964 study performed for IDNR is a more detailed estimate of the firm yield which considered downstream uses and 26 years of stream flow records, including severe drought years. Per our conversations with IDNR and the USACE, the previously estimated firm yield of 70 mgd is considered accurate. Based upon the 1964 study and projected average day (AD) demands, Lake Monroe has sufficient yield to satisfy CUD's needs throughout and well beyond the study period.

4. WATER SUPPLY

C. RAW WATER QUALITY

A summary of recent annual average water quality monitoring results for Lake Monroe is presented in Table 4-1, and the maximum annual recorded values are summarized in Table 4-2. This information suggests that no significant changes in raw water quality occurred during the 2002 to 2006 monitoring period reviewed. Raw water quality prior to 2002 was evaluated in the LRWCP. Lake Monroe exhibits relatively stable water quality characteristics, as would be expected for a relatively large multi-purpose impoundment. Lake Monroe is subject to periodic episodes of elevated iron and manganese concentrations, taste and odor occurrences (typically during the early fall months), elevated turbidity levels attributable to runoff associated with rainfall events and reservoir mixing associated with wind/wave action. However, maximum levels of these constituents have not been high enough to preclude effective treatment using conventional unit treatment processes.

Table 4-1
Lake Monroe Water Quality Data (Annual Average Values)

Constituent	2002	2003	2004	2005	2006
Turbidity, NTU	7.6	5.5	7.7	7.3	8.0
Alkalinity, mg/L $CaCO_3$	27.3	27.6	27.5	27.5	33.5
pH	7.3	7.3	7.4	7.5	7.3
Total Hardness, mg/L $CaCO_3$	46.4	47.1	47.0	46.4	45.7
Iron, mg/L	0.34	0.20	0.38	0.30	0.33*
Manganese, mg/L	0.08	0.03	0.07	0.07	0.06*
Odor	-	2.1	1.9	2.3	2.1
Total Organic Carbon, mg/L	3.54	2.98	2.86	3.37	3.21
UV254, cm^{-1}	0.109	0.084	0.079	0.092	0.095

* Data through October 2006

Table 4-2
Lake Monroe Water Quality Data (Maximum Annual Values)

Constituent	2002	2003	2004	2005	2006
Turbidity, NTU	22	21	20	26	58
Iron, mg/L	0.77	0.39	1.15	0.73	1.25*
Manganese, mg/L	0.42	0.08	1.20	0.33	0.15*
Odor	-	3.0	6.0	7.3	4.0
Total Organic Carbon, mg/L	4.3	3.4	3.4	4.4	4.1

* Data through October 2006

D. SEDIMENTATION

The issue of sedimentation and the effect on the long-term use of Lake Monroe as a water supply source was investigated. Based upon sedimentation and the USACE's latest study for Lake Monroe in October 1999 - *Water Control Manual*, the life of Lake Monroe remains 1966 to 2066. The USACE designs reservoirs such as Lake Monroe for a useful life of 100 years based upon a determined sedimentation rate. It is noted this does not mean the lake will no longer be usable after 100 years but that improvements may be required to extend the life of the reservoir. Some examples of improvements are as follows:

- The lake may need to be dredged to remove sediments.
- The water pool elevation may need to be raised to provide additional usable capacity.
- The effluent structure may need to be rehabilitated.
- The dam may need to be rehabilitated to extend the life of the reservoir.

The USACE indicated they would perform a more detailed study for a solution if sedimentation became a problem.

The impacts from possible solutions to sedimentation in Lake Monroe vary. Dredging the lake could cause water quality problems from disturbances to the lake bottom. The effects on treatment from dredging should be further evaluated prior to dredging. Raising the water pool elevation would ultimately be determined by the USACE; however, immediate impacts to the Monroe Intake Facility are not anticipated from this as the intake can withdraw water at various depths. Some localized improvements may be required to the site. The access road varies from elevation 570.0 to 538.0 and may require modifications if the pool elevation is raised.

CUD has indicated the possibility of localized sedimentation around the Monroe Intake Facility. The Monroe Intake Facility is located on the shore of Lake Monroe. The Intake Facility is divided into two cells, each equipped with three inlet ports for selective withdraw of water at different depths. The inlet ports are located at elevations 510, 520 and 530 feet and are equipped with sluice gates to control flow. At each port, water passes through a manual bar screen into a compartment and then through a traveling screen into a wetwell. Each wetwell contains two low service pumps, which convey water to the treatment plant through a 36-inch transmission main. The low service pumps are located on the operating floor at elevation 566.0. It is recommended that a local inspection around the Monroe Intake Facility be performed periodically to determine any local sedimentation problems. Dive inspections should be performed at a minimum every five years around the exterior of the intake to determine any possible problems.

E. CLIMATE CHANGE IMPACTS

Per American Water Works Association (AWWA) 2006 *Climate Change and Water Resources* guide, local climate change impacts, such as on Lake Monroe, are currently undetermined. The majority of the studies to date have been on coastal or mountainous regions that rely heavily upon changes in the weather for water supply. The water supply in these regions rely more on watershed storage than on reservoir storage. It is recommended that CUD continue to evaluate impacts of climate change as more information becomes available.

4. WATER SUPPLY

F. LONG TERM VIABILITY

Based upon our investigation, Lake Monroe has sufficient safe yield beyond 2060 based on water demand projections. It is recommended that CUD consider discussions with IDNR to secure the water supply into the future from Lake Monroe as it is a viable and reliable long-term source. Any increase in water supply should coincide with any increase in plant treatment capacity.

5. TREATMENT TECHNOLOGIES

A. WATER QUALITY GOALS

In order to identify unit process options which should be considered for new or expanded treatment facilities, key treatment objectives and water quality goals need to be established. The following “baseline” assumptions were developed to guide the identification and selection of appropriate treatment processes:

- The quality of the finished water will meet or exceed that required by current and anticipated future state and federal regulations.
- To the maximum extent practical, multiple treatment barriers should be provided.
- Provisions for effective control of taste and odor will be included.
- If a new treatment plant is considered, the finished water from the new plant will be fully compatible with the water currently produced by the Monroe Water Treatment Plant (WTP) with respect to chemical stability/corrosion protection capabilities and disinfectant residuals.
- The high quality of the finished water produced at the WTP is maintained throughout the distribution system.

In addition to these baseline assumptions, additional specific water quality goals were established and are summarized in Table 5-1. Ability to achieve these performance goals will ensure the continued production of high-quality finished water that meets consumer expectations and assures compliance with all applicable water quality and treatment requirements.

5. TREATMENT TECHNOLOGIES

Table 5-1
Suggested Water Quality Goals

Parameter	Goal
Turbidity	♦ Settled water turbidity should be less than 2 NTU ♦ Combined filter effluent turbidity should be ≤ 0.10 NTU for 95% of samples ♦ Individual filter effluent turbidity should be ≤ 0.15 NTU for 95% of samples
Disinfection Byproducts	♦ DBPs should be ≤ 75% of the MCL at any time ♦ Average DBP concentration should be ≤ 50% of MCL
Microbial Pathogens	Provide for removal/inactivation of *Cryptosporidium* oocysts
Total Organic Carbon	Maintain minimum of 35% removal
Iron	Finished water concentration ≤ 0.05 mg/L at all times
Manganese	Finished water concentration ≤ 0.02 mg/L at all times

B. PENDING REGULATORY CONSIDERATIONS

While regulations governing the quality of drinking water have evolved continually since the enactment of the Safe Drinking Water Act (SDWA) in 1974, the pace at which new regulations are issued has increased significantly since the enactment of amendments to the Safe Drinking Water Act in 1986 and 1996. In January 2006, the U.S. Environmental Protection Agency (USEPA) finalized two long-awaited drinking water regulations that will have an impact on virtually all U.S. water utilities, and could require some utilities to make costly changes in their treatment systems in order to achieve compliance. The Stage 2 Disinfectants and Disinfectants and Disinfection Byproducts Rule (Stage 2 DBPR), which is intended to reduce exposure to potentially harmful disinfection byproducts (DBPs) in drinking water, focuses on reducing DBPs uniformly throughout the distribution system to ensure that health risks to all consumers are minimized. Additionally, the intent of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) intends to provide additional protection from waterborne disease-causing microorganisms, in particular, *Cryptosporidium*, a chlorine-resistant pathogen implicated in several waterborne disease outbreaks. These two rules were developed concurrently in order to balance trade-offs in risk between the control of pathogens and the desire to limit exposure to DBPs.

Under the Stage 2 DBPR, systems will be required to maintain running annual average total trihalomethane (TTHM) concentrations of 0.080 milligrams per liter (mg/L) or lower and haloacetic acid (HAA5) concentrations of 0.060 mg/L or lower at each compliance monitoring location within the distribution system, rather than following the current practice of averaging the results for all system monitoring locations. Initial compliance efforts will focus on identifying points within the system where DBP concentrations are typically highest, and for most systems will involve one year of expanded monitoring of TTHM and HAA5 concentrations. This monitoring, referred to as the Initial Distribution System Evaluation (IDSE) process, must be conducted in addition to the routine quarterly compliance monitoring required under the Stage 1 DBPR, and results will be used to select new routine compliance monitoring sites. Options under which systems can meet the IDSE provisions of the Stage 2 DBPR include collection of new system DBP data through a Standard Monitoring Program (SMP) or the use of qualifying existing system DBP monitoring data or data from extended-period simulation hydraulic models capable of predicting water age within the system through a System Specific Study (SSS). Systems that can certify that all of their recent existing DBP monitoring results are equal to or less than half of the TTHM and HAA5 maximum contaminant levels (MCL), also known as 40/30 certification, will be able to obtain exemptions from IDSE monitoring requirements. Schedules for submittal and approval of proposed IDSE monitoring plans, actual system monitoring, and report submittal are phased based on system size. However, consecutive systems, which are systems that receive a portion or all of their finished water from one or more wholesale systems, must also comply with the sample plan submittal, system monitoring, and report submittal schedule of the connected system subject to the earliest compliance dates.

5. TREATMENT TECHNOLOGIES

The LT2ESWTR builds upon earlier rules, and applies to all systems using surface water sources or groundwater sources subject to direct surface water influence. Systems serving 10,000 or more customers must initially monitor their source water for *Cryptosporidium* at least monthly over a two-year period. Systems with *Cryptosporidium* concentrations that exceed the specified levels will be required to provide additional treatment over and above the levels currently provided by their conventional processes, as shown in Table 5-2. Systems can choose technologies to comply with these additional treatment requirements from a "toolbox" of options outlined in the LT2ESWTR. Microbial toolbox options include improved watershed control, improved treatment system and/or disinfection performance, and providing additional treatment barriers. The LT2ESWTR also includes new requirements for disinfection profiling/ benchmarking for those systems that will need to make significant changes in disinfection practices to comply with both the LT2ESWTR and the Stage 2 DBPR.

Table 5-2
Treatment Bin Classification and Additional *Cryptosporidium* Treatment Requirements

Average Raw Water *Cryptosporidium* Concentration, oocysts per Liter	Treatment "Bin" Classification	Additional *Cryptosporidium* Inactivation/Removal Requirements for Specified Treatment Process	
		Conventional Filtration (including softening)	Alternative Filtration Technology
< 0.075	1	None	None
0.075 to < 1.0	2	1-log	[1]
1.0 to < 3.0	3	2-log[2]	[3]
≥ 3.0	4	2.5-log[2]	[4]

[1] As determined by the State such that total *Cryptosporidium* removal/inactivation is at least 4.0-log.
[2] At least 1-log additional treatment must be provided by bag filters, bank filtration, cartridge filters, chlorine dioxide, membranes, ozone and/or UV.
[3] As determined by the State such that total *Cryptosporidium* removal/inactivation is at least 5.0-log.
[4] As determined by the State such that total *Cryptosporidium* removal/inactivation is at least 5.5-log.

5. TREATMENT TECHNOLOGIES

For many utilities, the need to achieve higher levels of treatment to control microbial pathogens while simultaneously meeting the more stringent limits on disinfection byproducts will be challenging. Most utilities will want to consider an approach consisting of optimization of current treatment practices to maximize particulate removal and/or pathogen inactivation capabilities, coupled with the addition of further enhancements and/or new treatment technologies, if necessary to achieve compliance.

1. Applicability to the City of Bloomington Utilities Department/Recent Monitoring Results

CUD initiated the required two years of monthly source water *Cryptosporidium* monitoring under the LT2ESWTR during October 2006, and must begin conducting the required IDSE monitoring under the Stage 2 DBPR during October 2007. While CUD currently serves approximately 70,000 customers and would therefore be considered a “Schedule 2” system based strictly on customers served, CUD is considered by the Indiana Department of Environmental Management (IDEM) to be a “Schedule 1” system due to consecutive/interconnected system issues, and is therefore required to conduct this monitoring on a slightly accelerated schedule.

As shown in Table 5-3, current disinfection practices yield DBP concentrations in the finished water that are consistently well below maximum allowable levels at all current monitoring locations. As a chloramine residual is maintained in the finished water, DBP concentrations throughout the system served by the Monroe WTP are fairly consistent, and it is expected that the expanded system DBP monitoring required under the Stage 2 DBPR (IDSE monitoring) will not identify locations where DBP concentrations are significantly higher than current system monitoring locations. Therefore, the Stage 2 DBPR is expected to have little or no significant impact on current treatment and system operations. A primary impact would be an increase in the number of required routine DBP sample locations from the current 4 sites to 8 sites. However, review of historical total organic carbon (TOC) concentrations for Lake Monroe suggests that concentrations are high enough to require chemical coagulation and/or adsorption to reduce finished water concentrations to levels that will ensure continued compliance with both current and pending DBP requirements.

Table 5-3
DBP Monitoring Results for CUD System (2003 – 2006)

DBP	MCL, ug/L	Running Annual Average Values, ug/L*			
		Marlin School	Service Center	College Mall	Hospital
TTHMs	80	41 - 61	33 - 55	34 - 58	32 - 51
HAA5	60	28 - 40	29 - 45	33 - 50	31 - 46

* Results for four quarterly monitoring periods per year

As previously indicated, monitoring of Lake Monroe for *Cryptosporidium* was recently initiated and will not be completed until September 2008. Therefore, the need for additional treatment for removal/inactivation of *Cryptosporidium* cannot be determined until monitoring is complete. However, source water monitoring results obtained thus far have been consistently negative with respect to presence of *Cryptosporidium*.

C. TREATMENT TECHNOLOGIES

Unit treatment process technologies that could be used to achieve the water quality objectives are as follows.

1. Pretreatment

The nature and extent of pretreatment has a dramatic impact on the efficiency of subsequent filtration processes. There are several pretreatment technologies that would potentially be appropriate for new or expanded treatment facilities. A discussion of the most commonly used unit pretreatment processes are discussed as follows:.

a. Conventional Coagulation and Sedimentation

Conventional treatment consists of chemical coagulation, flocculation, and gravity sedimentation. Coagulant chemicals, such as aluminum or iron salts or organic polymers, electrically neutralize the negative charge on most particles in the raw water. Rapid mixing is used to thoroughly disperse the coagulant chemicals into the raw water. Flocculation involves gentle mixing of the chemically-coagulated water to promote the agglomeration of the coagulated particles into larger, readily settleable floc particles. Well-designed flocculation facilities include provisions for tapering of the flocculation energy imparted to the flow as it progresses through the basins, thereby promoting the formation of a uniform, rapidly settling floc which can be readily removed in sedimentation basins. Typical hydraulic residence times for conventional flocculation of surface water are 20 to 45 minutes, and typical hydraulic retention times for gravity sedimentation basins at loading rates of 0.35 to 0.5 gallons per minute per square foot (gpm/ft^2) are 3 to 4 hours. Tube settler modules may be added to increase effective basin treatment capacities by factors of 2 to 4. The existing sedimentation basins at the Monroe WTP were equipped with tube settlers in 1990 to increase treatment capacity and the original tubes were recently removed and replaced with new modules in 2005. Provisions for mechanical collection and removal of settled floc are usually included in the design of sedimentation facilities. Well-designed and operated conventional coagulation/sedimentation systems can consistently produce settled water with a turbidity of 1 to 2 nephelometric turbidity units (NTU) or lower.

Conventional coagulation, flocculation, and sedimentation, in conjunction with granular media filtration, have been demonstrated to be capable of removing turbidity, color, DBP precursor compounds, viruses, bacteria and protozoans such as G*iardia* cysts and *Cryptosporidium* oocysts. Removal of naturally-occurring organic material is dependent on the pH maintained during treatment, coagulant dosage and the type(s) of organic material present. Removal of microbiological contaminants such as bacteria and protozoans can be as high as 3-log to 4-log (99.9 to 99.99%). Viruses are more difficult to remove, but removals exceeding 2-log (99%) have been demonstrated for conventional treatment when filtered water turbidity is very low. Well-operated conventional plants employing coagulation, sedimentation and filtration processes can produce filtered water with a turbidity of 0.10 NTU or less. To consistently achieve low filtered water turbidities, the turbidity of the settled water should typically be maintained at 1 to 2 NTU or lower.

Conventional treatment is currently the most widely-used process configuration for potable water production, as it is well-understood by most operators and readily accepted by state regulatory agencies. However, because required basin sizes are significantly larger than for many of the newer high-rate processes, construction costs may be higher than for other alternatives. Also, as this process relies upon gravity settling of floc particles, performance typically declines during periods when water temperatures are lower due to the higher water densities and associated reductions in floc settling rates.

b. Inclined Plate Sedimentation

Based on shallow depth sedimentation theory, basins equipped with inclined plates can yield high particle/floc removal efficiencies with significantly smaller basin footprint areas than conventional sedimentation basins. Plates are typically inclined 55 degrees from horizontal and spaced 2 to 4 inches apart, which results in large "effective" settling area within a relatively small basin area. Flocculated water enters at or near the bottom of the plates, and flows upward between the plates. Typical loading rates based on "effective" or "projected" plate area are 0.25 to 0.5 gpm/ft^2, and yield overall sedimentation basin loading rates of 4 to 8 gpm/ft^2, which are significantly higher than for conventional sedimentation basins. Successful operation is dependent upon maintaining optimal flocculation performance and flow distribution between the flocculation basins and the plates. While most new basins constructed with inclined plates are at least 18 to 20 feet deep in order to optimize flow distribution, turbidity removal, and ability to remove the settled solids from the basins, existing basins with sidewall depths of at least 15 to 16 feet can typically be retrofitted with inclined plates.

The superior flow distribution and high degree of hydraulic uniformity provided by the inclined plate system typically yields improved turbidity removal performance as compared to conventional sedimentation operating under equivalent coagulant dosage conditions. The significantly smaller sedimentation basin footprint area required may also result in savings in initial construction costs. As operational requirements for basins equipped with inclined plates are essentially identical to those for conventional flocculation/sedimentation basins, inclined plate-equipped basins are often the preferred option for plants with existing conventional pretreatment processes.

c. Dissolved Air Flotation

Dissolved air flotation (DAF) is based on the principle that for some waters, naturally occurring and coagulated particles “float” better than they settle. In the DAF process, fine air bubbles are injected into the process flow following coagulation and flocculation. These bubbles attach themselves to the floc particles and float them to the water surface, where they are removed by mechanical skimming or by flushing to a collection trough through periodic increases in basin water surface elevation. Approximately 5 to 10 percent of the clarified DAF process effluent is typically pumped through an air saturation system and then pressurized prior to recycling the DAF basin influent. Release of this pressurized flow through a series of nozzles or orifices produces microbubbles ranging in size from 10 to 100 microns. The clarified flow is removed from the bottom of the DAF flotation basin, rather than from the surface as for conventional sedimentation.

DAF is often the preferred treatment method for low-turbidity waters with high color, and/or algae/diatom levels that may rapidly clog granular media filters, and considered less efficient for treating waters with high turbidity and silt/sand content. As DAF basins are typically fairly shallow (10 to 12 feet or less), the process can often be retrofitted into existing conventional flocculation/ sedimentation basins. Either aluminum or iron-salt coagulants can be used as the coagulant. Flocculation provides mixing energy for particle growth; however, particles need not be of sufficient size for settling, as for conventional sedimentation. Therefore, required flocculation times used in DAF plants are typically less than those used by conventional treatment plants. Hydraulic retention times for flocculation preceding DAF are typically 15 to 20 minutes, and conventional DAF basins are designed with hydraulic loading rates ranging from 4 to 6 gpm/ft^2. Some high-rate DAF systems have been designed with loading rates of up to 15 gpm/ft^2. Full-scale operating experience has demonstrated that DAF can typically produce low-turbidity settled water at coagulant dosages that are less than required for similar performance using conventional sedimentation processes. However, it should be noted that at lower coagulant dosages, removal of natural organic matter and DBP precursor compounds may be less effective. Under low water temperature conditions, the DAF process also is generally capable of producing an effluent with lower turbidity than for conventional treatment.

The primary disadvantage of DAF systems is the power costs associated with operation of the recycle stream saturation and pumping systems. Also, the shorter residence times within DAF systems as compared to conventional treatment processes may make the DAF process more susceptible to over- or underdosing of coagulants and to changes in raw water quality. However, for source waters of appropriate quality, DAF clarification is as effective as gravity settling, and a treatment plant having a DAF clarifier should be considered the equivalent of a conventional treatment plant in terms of ability to remove viruses, bacteria, and *Giardia* and *Cryptosporidium*.

5. TREATMENT TECHNOLOGIES

d. Ballasted Clarification

Ballasted clarification and settling (e.g. Kruger Actiflo® process) is a precipitative process which accelerates conventional clarification through attachment of floc particles to microsand with the aid of polymer. The process involves four distinct stages:

- Chemical coagulation
- Injection of microsand and polymer
- "Maturation", where the floc particles agglomerate and are attached to the microsand
- Sedimentation.

The settled floc/microsand particles are collected and pumped through a cyclone separation process, where the microsand is separated from the floc particles and returned to the treatment process, and the floc particles are directed to disposal. The microsand weighted floc particles have very high settling rates, which substantially reduces the size of the sedimentation facilities required. Typical hydraulic retention times are 6 to 10 minutes for the coagulation, injection, and maturation processes, and less than 15 to 20 minutes for the entire process. Hydraulic loading rates within the sedimentation zone are typically 20 to 30 gpm/ft^2, and the settling zone is equipped with tube modules to ensure effective clarification. The ballasted clarification process can produce settled water with turbidities of 0.3 to 0.5 NTU or lower, even under highly variable raw water temperature and turbidity conditions, and can usually be retrofitted into existing conventional flocculation/sedimentation basins.

Advantages of ballasted processes include reduced coagulation and flocculation times and a much higher settling rate compared to conventional settling. This translates into a smaller required basin footprint area, and corresponding savings in construction costs, particularly if enclosure of the treatment process is desired. For some waters, required chemical dosages for satisfactory coagulation/

clarification are lower for ballasted clarification than for conventional treatment. Because of the short detention times within the process, steady-state conditions are achieved quickly as compared to conventional processes. The ballasted clarification process has been successfully employed even under extreme low temperature, high color, and high turbidity conditions, and has demonstrated ability to achieve high algae removals (approximately 90 percent) essentially equivalent to the DAF process. Ballasted clarification is also effective for pathogen removal, and has demonstrated the ability to achieve *Cryptosporidium* oocyst removals exceeding 4-log.

The primary disadvantages of the ballasted clarification are its dependence on polymer and the impact of a sudden loss of polymer feed capability on settled water quality. Residual polymer carryover to downstream filtration process (granular media or membranes) has been shown to be problematic for some systems.

e. Sludge Blanket Clarifiers (IDI Superpulsator®)

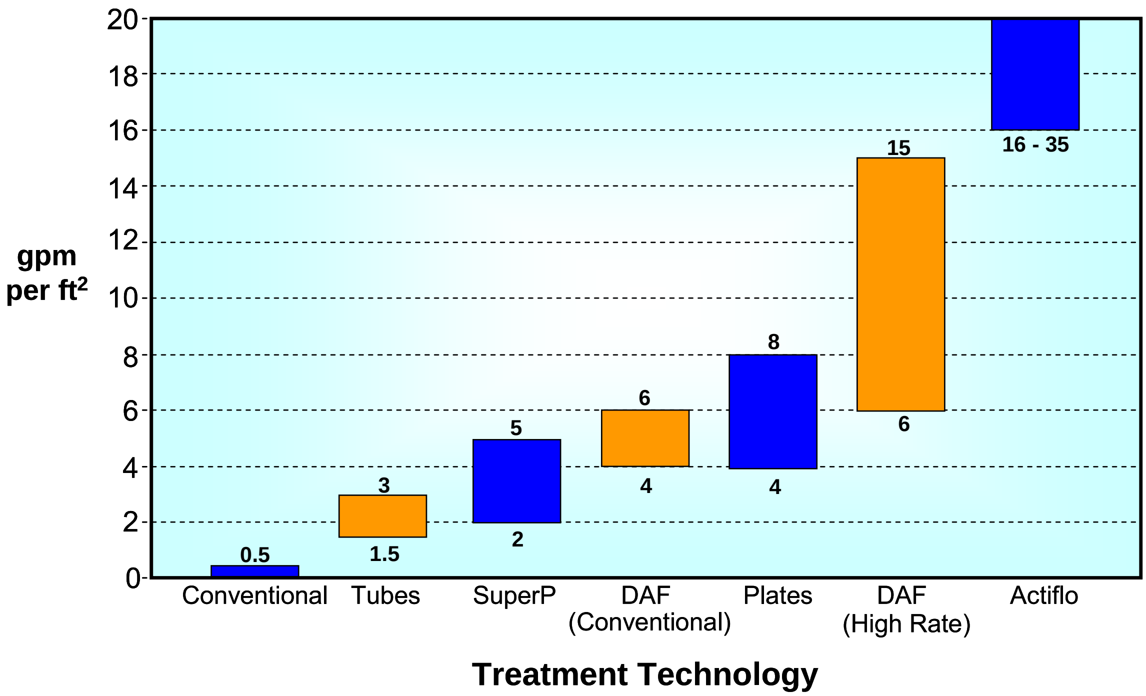
The Superpulsator® clarifier is a high-rate process that combines flocculation and sedimentation/solids separation in a single unit. These clarifiers are designed to maintain a large mass of flocculated solids within the unit, with the incoming coagulated water passing upward through a “blanket” of flocculated solids, thereby maximizing interparticle collisions and increasing overall flocculation and particle removal efficiency. Addition of a polymer is generally required to maintain sludge blanket cohesion and to maximize particle removal efficiencies at high clarifier throughput rates. Unlike a conventional upflow sludge blanket clarifier, the Superpulsator® utilizes a vacuum pump and influent vacuum chamber to produce a pulsating effect which results in alternate expansion and contraction of the sludge blanket, thereby maintaining blanket uniformity. A complete pulsation cycle typically occurs every 40 to 60 seconds. Inclined plates installed above the sludge blanket assist in removal of floc particles not retained within the sludge blanket, and allow operation at effective surface loading rates typically ranging from 2 to 4 gpm/ft^2, with most installations having loading rates of approximately 2.0 to 2.5 gpm/ft^2. In the case of the newer Superpulsator® Type U clarifier, an additional layer of tube settler modules is installed above the inclined plates.

Maximum sludge blanket surface elevation is maintained at a predetermined level through use of a solids overflow weir. During each pulsation cycle, a portion of the solids present in the sludge blanket are discharged over this weir to a collection hopper, and are periodically discharged by gravity flow from the clarifier. Typical solids concentrations in the sludge discharged from the Superpulsator® clarifier range from 0.5 to 2 percent. There are no submerged moving parts or mechanisms, and the ability to retain significant amounts of powdered activated carbon within the sludge blanket may be advantageous where problems with raw water taste and odors are periodically experienced. Power consumption is also lower than for other pretreatment/clarification options. However, longer operating periods are typically required after startup to achieve steady-state conditions due to the need to develop an effective sludge blanket. Experience at other utilities also suggests that this type of clarifier may not respond well to changes in influent quality and/or temperature, or to rapid increases in influent flow rates.

Figure 5-1 summarizes the ranges of hydraulic loading rates for the pretreatment technologies discussed herein.

5. TREATMENT TECHNOLOGIES

Figure 5-1 Hydraulic Loading Rates



2. Filtration

Filtration is normally the final barrier for removal of particulate material from water prior to distribution. These particulates consist primarily of flocculated mineral particles, such as clay and silts, but may also include pathogens such as bacteria, viruses, and protozoa, including *Giardia* cysts, *Cryptosporidium* oocysts. As filtration is a primary pathogen barrier during water treatment, proper filter process selection is critical to delivery of safe and aesthetically acceptable finished water to consumers. There are two general types of filters in use for water treatment, granular media filters and membrane filters. Each type offers benefits and disadvantages with respect to water quality and operation, as discussed below.

5. TREATMENT TECHNOLOGIES

a. Granular Media Filtration

Granular media filters can be classified by media type and bed configuration, hydraulic driving force and operating rate. Granular media types include sand, anthracite, garnet, and granular activated carbon (GAC), while bed configuration can be monomedia, dual media, mixed multi-media, or deep bed monomedia. Filter hydraulic driving force is provided by gravity or pressure. The rate is either slow sand, rapid, or high-rate filtration. For granular media filters to perform properly, particles must have their surface charge modified during pretreatment to allow them to readily attach to the filter media. Filtration performance is heavily dependent on the level of pretreatment provided, type of particles to be removed, and filter media configuration. Extensive operating experience within the water industry has not conclusively identified a media configuration that is clearly superior to others with respect to particle removal capability.

As water passes through a granular media filter, the pores between grains of media become filled with particles, and unless energy is applied to maintain the filter rate, the filter rate will decline. The energy is normally provided by maintaining sufficient depth of water above the filter, and is referred to as hydraulic head. The additional energy required to push the water through the filter is typically referred to as head loss. The maximum available head loss for most gravity granular media filters is between 8 and 10 feet of water and is dependent upon the maximum water depth above the filter. Filter productivity is defined as the amount of water that can be filtered prior to having to remove the filter from service for backwashing due to excessive head loss accumulation or turbidity breakthrough. Typically, filters with effective pretreatment can operate for 12 to 96 hours before either reaching the head loss limit or experiencing turbidity breakthrough. As the filtration rate (expressed as gpm treated per square foot of media area) increases, the rate of head loss accumulation will also increase. Although head loss accumulation should be minimized to maintain adequate filter run times, increased filter productivity gained by utilizing higher filtration rates may outweigh the accelerated rate of head loss accumulation. The effective size of the filter media has a significant impact on the rate of head loss accumulation. In general, coarse media allows for greater penetration of particles within the filter bed than fine media. This translates to a lower rate of head loss accumulation, longer filter runs, and potentially greater water production. Conversely, fine particles tend to penetrate further within a coarse media, greater depths of coarse media than fine media are necessary to achieve the same particle capture. Filter media design is therefore a balance between media size and depth in order to achieve high filter productivity and acceptable particle capture/removal.

Use of filters equipped with two or more layers of media with different effective sizes and densities to allow for restratification following backwashing yields optimal particle removal capabilities while minimizing head loss accumulation rates. Dual media filters consist of 20 to 40 inches of anthracite coal or GAC, over a layer of 10 to 12 inches of fine sand. The upper layer is relatively coarse, allowing greater penetration of particles in the filter bed, thus minimizing head loss accumulation. The sand layer (beneath the anthracite or GAC) functions as a final barrier to fine particles. In some cases, a 3 to 4 inch layer of fine garnet is added below the sand layer (this media configuration is typically referred to as "mixed media" or "multimedia") to provide additional particle removal. The existing Monroe WTP filters are equipped with mixed media. Dual media and mixed media filters typically operate at maximum loading rates of 4 to 6 gpm/ft^2. Filters equipped with a single deep bed of coarse medium have been constructed that can achieve filtration rates of up to 10 gpm/ft^2. These filters are typically anthracite with an effective size of 1.2 to 1.5 millimeters (mm), and have a depth of 5 to 6 ft. More shallow media depths (approximately four feet) have also demonstrated the ability to produce excellent filtered water when operated at hydraulic loading rates of 5 to 6 gpm/ft^2.

Filters that are not preceded by disinfection or addition of chemical oxidants can be operated in a biologically active mode. In addition to the removal of turbidity and suspended particles, biological filtration can be used to remove byproducts of ozone disinfection/oxidation, DBP precursors, and taste and odor-causing compounds. Biological filtration also improves the stability of the treated water through removal of organic compounds that may encourage regrowth of coliforms and formation of biofilm within the distribution system. Biological filtration typically reduces the oxidant demand of the finished water, which results in a more stable, consistent disinfectant residual throughout the distribution system. Biological filtration utilizes innocuous microorganisms on the filter media to break down and remove biodegradable compounds known as biodegradable organic matter (BOM). The key to successful operation of biological filters is accumulation and maintenance of a sufficiently large mass of microorganisms that will consume BOM. When GAC is used in a biologically active filtration system, it functions in both biological and adsorption modes. Dissolved organics are removed from solution by adsorption, and BOM is mineralized, ultimately converted to carbon dioxide and water. The porous structure of GAC provides an excellent location for attachment of the microorganisms that are responsible for initiating and maintaining the biological filtration process. Operation of GAC filters in the biologically active mode extends the useful life of the media considerably beyond the lifespan of GAC in an adsorption-only mode.

b. Membrane Filtration

Membrane filtration, which involves removal of suspended particles using low-pressure hollow fiber membranes, is becoming increasingly popular as an alternative to conventional granular media filtration processes. Microfiltration (MF) and ultrafiltration (UF) are physical processes in which colloidal particles are removed from the water supply by straining through a porous medium. Both processes provide exceptional removal of turbidity; most operating facilities routinely produce treated water with turbidities of less than 0.05 NTU. MF membranes typically used for treatment of surface water supplies are hollow-fiber with a nominal pore size of 0.1 to 0.5 microns. UF membranes used in surface water treatment applications typically exhibit a nominal pore size of 0.01 to 0.05 microns. As these pore sizes are significantly smaller than *Cryptosporidium* oocysts (2 to 7 microns) and *Giardia* cysts (5 to 15 microns), MF and UF provide excellent removal of these microbial contaminants. Removal of *Giardia* cyst-sized particles in excess of 6 to 8 logs (99.9999 to 99.999999 percent) have been demonstrated during pilot-scale testing, and therefore many states grant 3-log and in some cases 4-log removal credits for MF and UF treatment.

Typical average feedwater pressures for conventional “encased” membrane configurations are 10 to 20 pounds per square inch (psi). Backwashing of MF/UF modules is typically initiated every 30 minutes (up to 60 minutes for exceptionally clean feedwaters), and the backwash cycle typically lasts approximately two minutes. Backwashing typically uses approximately 5 to 7 percent of the feedwater pumped to an MF system; however, recycling of the backwash flow to the plant influent following treatment to remove settleable solids can reduce overall losses to about 1 percent of plant production. Periodic cleaning with citric acid, caustic/ hypochlorite solution, and/or proprietary detergent solutions may be required when conventional backwashing can no longer restore differential pressures across the membranes to original levels. Chemical cleaning is typically conducted at 4 to 6 week intervals. In some cases, cleaning is augmented by more frequent, automated chemically-enhanced backwash cycles.

Another membrane option is the “immersed” or “submerged” membrane configuration. Submerged membrane systems consist of “modules” of membrane fibers suspended in conventional concrete or steel tanks containing the water to be treated. Unlike encased membrane systems, where the feedwater is pressurized to force the feedwater through the membranes, submerged membranes operate under a slight vacuum, typically 4 to 10 psi. A vacuum is produced by pumps located on the product water side of the membranes, or in some cases when site topography permits, by siphoning action created by discharge of permeate well below the elevation of the membranes. The membranes are periodically “backpulsed” using product water to remove deposits on the membrane surfaces; this typically occurs every 30 minutes for a period of approximately one minute. Submerged membrane systems employ injection of air at the floor of the membrane chamber to scour the membrane surfaces and to maintain a homogeneous concentration of suspended solids within the chamber. Periodic chemical cleaning is required to maintain membrane flux rates, which is typically accomplished by backpulsing the membranes at a reduced rate with concentrated cleaning solutions. Cleaning solutions typically include sodium hypochlorite and proprietary detergent solutions. The cleaning process is usually automated to reduce operator involvement. Most existing submerged membrane systems operate at raw-to-product recovery rates of approximately 95 percent. However, through recycling of the membrane reject stream and/or use of "secondary" membrane treatment systems, overall treatment process losses can typically be reduced to about one percent of the raw water treated.

As MF and UF treated water exhibits extremely low turbidities, which are difficult to accurately monitor, provisions for continuous monitoring of treated water particle counts are required to ensure that the membranes are operating properly. It is also typically recommended that an air integrity test be conducted at least once per day to ensure that the membranes and associated gaskets/seals are functioning properly, and that individual membrane fibers have not failed. At least one state currently requires that membrane integrity testing be conducted every eight hours for new plants until stable operations are demonstrated.

A potential advantage of submerged membranes is their ability to be located in existing plant structures, such as filter boxes as a replacement for the conventional granular media. Minimum required basin depth for the submerged membranes is approximately 9 to 10 feet, and membrane production rates at "conservative" hydraulic loading (flux) rates are approximately 6 to 10 gpm/ft^2 of basin plan area. As MF/UF systems lend themselves well to high levels of automation, they are also generally easier to operate than conventional granular media filters. Although membrane systems are more capable of tolerating poor feed water quality than granular media filters, pretreatment by a more conventional treatment process prior to membrane filtration will typically result in higher acceptable membrane flux rates, reduced cleaning intervals, and lower capital costs.

3. Disinfection

a. Chlorine/Chloramines

Chlorine continues to be the most widely-used disinfectant/oxidant for both primary disinfection and for maintenance of a disinfectant residual in the distribution system. Free chlorine is significantly less expensive than other disinfectants, and is effective for inactivation of many microorganisms. However, chlorine has several disadvantages, including the inability to inactivate *Cryptosporidium* oocysts, and the formation of halogenated disinfection byproducts.

Chloramines are formed when free chlorine is combined in water with ammonia. Because chloramines are not as effective for inactivation of most microbial organisms as free chlorine, they are normally used as secondary disinfectants within the distribution system, rather than as primary disinfectants. Unlike free chlorine, they do not promote the formation of halogenated byproducts; however, byproducts that may be of future concern are N-nitrosodimethylamine (NDMA) and cyanogen chloride. Presently neither of these compounds is regulated in drinking water, partially because there is little definitive information regarding their health risks or the concentrations at which they may become a cause for concern. According to available data, they are present in chloraminated water only at very low concentrations.

CUD currently uses free chlorine for primary disinfection, followed by conversion of the residual to chloramines to limit DBP formation and to provide a stable, persistent disinfectant within the distribution system.

5. TREATMENT TECHNOLOGIES

b. Chlorine Dioxide

Chlorine dioxide (ClO_2) is a very effective disinfectant/oxidant currently used by more than 500 water utilities either continuously or seasonally for disinfection, taste and odor control, oxidation of iron and manganese, and/or to reduce chlorine-based disinfection byproducts in finished water. It is used most frequently early in the treatment process as a substitute preoxidant for free chlorine. Substitution of ClO_2 for chlorine at the head of the treatment plant not only allows chlorination to be delayed until coagulation, flocculation, and settling are completed, but also chemically alters DBP precursor compounds by partially oxidizing them, which makes them less amenable to halogenation when chlorine is applied. Because of its unstable nature, ClO_2 must be generated onsite. Byproducts of oxidation with chlorine dioxide include chlorite and chlorate ion. Chlorite concentrations in the finished water are currently regulated and the chlorite ion can be removed by adding ferrous iron, which ultimately results in conversion of chlorite to chloride ion.

c. Ozone

Ozone is currently the most powerful oxidant and disinfectant available to the water industry and has been used to disinfect water in Europe for more than 100 years. More than 200 U.S. plants are currently using ozone or have ozone systems under design or construction. In addition to disinfection, direct benefits of using ozone include reduction of tastes and odors, improvements in filtered water turbidity when applied immediately preceding filtration, microcoagulation of dissolved organic contaminants, and oxidation of color, iron, and manganese. Ozone is applied in gaseous form and, because of its instability, is generated onsite. Most of the known byproducts of ozonation can be readily removed to acceptable levels by biologically active filtration. However, continued concerns regarding the potential health impacts of bromate may limit the use of ozone if effective bromate formation control measures cannot be implemented. Bromate is a byproduct of ozonation of waters containing low levels of bromide, and a suspected carcinogen. While ozone is effective for inactivation of *Cryptosporidium* oocysts in warm water, its effectiveness decreases rapidly at temperatures lower than five degrees Celsius, which may reduce its attractiveness for inactivation of this microbial contaminant in areas with colder source waters.

d. Ultraviolet Irradiation

Ultraviolet (UV) light, historically used in this country primarily to disinfect wastewater effluents, is rapidly emerging as the preferred primary disinfectant when provisions for inactivation of microbial pathogens such as *Giardia* and *Cryptosporidium* are required. There are more than 1,000 U.S. facilities that currently utilize UV for disinfection of public drinking water supplies. UV has demonstrated the ability to achieve 3.0-log to 5.0-log inactivation of *Cryptosporidium* oocysts and *Giardia* cysts.

Benefits of UV disinfection include:

- Significantly lower costs than for comparable microbial control processes (ozone, MF/UF)
- Small facility area requirements
- Ability to cost-effectively retrofit existing plant facilities
- Significant reductions in formation of halogenated DBPs (when free chlorine contact times following UV treatment are limited)
- High levels of achievable pathogen inactivation

Potential disadvantages include:

- The potential for fouling/plating of the quartz sleeves which house the UV lamps
- Reliability/accuracy of the UV sensors used to monitor process effectiveness

- Difficulties in securing state regulatory agency approval for disinfection of surface water supplies because of limited full-scale U.S. operating experience

UV system designs typically utilize medium-pressure or low-pressure high-output lamps enclosed in a stainless steel pipe-type reactor vessel, which facilitates incorporation into existing treatment facilities. Standby UV reactors are typically specified to provide reliability and to ensure continued plant operation should a single unit require servicing. USEPA's *Ultraviolet Disinfection Guidance Manual for the Long Term 2 Enhanced Surface Water Treatment Rule* (EPA 815-R-06-007; November 2006) recommends that UV systems be placed after the filtration process. Drawbacks to placing the reactors upstream of filtration include lower UV transmittance and the potential for coagulation to shield microorganisms, thereby hindering their inactivation. Also, the LT2ESWTR UV dose requirements apply only to post-filter applications and to unfiltered supplies that meet criteria for filtration avoidance.

The published LT2ESWTR dose requirements for inactivation of viruses by UV are based on adenovirus, which is more resistant to UV irradiation than poliovirus or rotavirus. Based on the dose tables, UV disinfection is not as cost effective for the inactivation of viruses as it is for the inactivation of *Giardia* and *Cryptosporidium.* Therefore, a brief free chlorine contact period either prior to or following UV would be required to ensure that conditions for positive inactivation of viruses are provided.

Evaluation of *Cryptosporidium* control requirements for other similar facilities indicates that both probable construction and annual operating costs associated with UV disinfection would be considerably less than for MF/UF membrane treatment or ozone disinfection.

5. TREATMENT TECHNOLOGIES

4. Taste and Odor Control

Discussions with CUD staff indicate that periodic taste and odor occurrences are sometimes difficult to adequately address using currently-available treatment methods. As ability to effectively deal with these taste and odor occurrences is critical in maintaining consumer confidence in the quality of the water delivered, it would be appropriate to consider all taste and odor control options during any expansion of the existing Monroe WTP or construction of a new treatment facility. The following summarizes taste and odor control options for a new or expanded treatment facility.

a. Current Taste and Odor Control Practices

CUD currently feeds powdered activated carbon (PAC) at the rapid mix chamber in response to periodic episodes of taste and odor in the source water, typically during the early fall months. A summary of recent PAC feed dosages is presented in Table 5-4. Current practices are reported to be ineffective in completely eliminating tastes and odors during periods when concentrations of odor-causing compounds in the source water are high. However, experience at other utilities suggests that PAC dosages required during moderate to severe periods of taste and odor may be as high as 30 to 50 mg/L. As shown in Table 5-4, recent applied PAC dosages at the Monroe WTP have been considerably less than these levels. The maximum PAC feed capability at the Monroe WTP at 24 mgd is currently 20 mg/L, based on rated feed pump capacities.

5. TREATMENT TECHNOLOGIES

Table 5-4
PAC Dosages at Monroe WTP

Year	Days Fed	Applied PAC Dosage, mg/L	
		Average	Range
2006	0	NA	NA
2005	23	11.6	0.7 – 16.6
2004	13	8.1	3.8 – 9.8
2003	13	10.3	3.8 – 18.3
2002	30	7.6	0.8 – 9.6
2001	29	7.1	1.0 – 18.6

PAC typically exhibits relatively high adsorptive affinity for taste and odor-causing compounds and naturally occurring organic matter. Factors that affect PAC performance include contact time between PAC and the target contaminants, interference from other chemicals added in the treatment process, and competition from other naturally-occurring organic compounds in the water being treated. When added in conjunction with coagulants, adsorption of organics to PAC can be inhibited by enmeshment of the PAC particles in coagulant flocs. Therefore, PAC should ideally be fed at a location upstream of the point of initial coagulant and/or oxidant addition to maximize the potential for adsorbing taste and odor-causing compounds. Many utilities have found that feeding PAC into the raw water pipeline upstream of the WTP headworks, such that at least 3 to 5 minutes of PAC contact time is provided within the pipeline prior to coagulant addition, is effective in dealing with most routine taste and odor occurrences. Some utilities have installed PAC feed capability at the raw water intake in order to maximize available contact times within the raw water pipeline prior to treatment.

An advantage of PAC adsorption as compared to other taste and odor control options includes the ability to be used “on demand” with low initial construction costs for the feed system. In addition, PAC is typically removed from the treatment process relatively quickly after it is settled out in the sedimentation process. This eliminates the potential for desorption of previously adsorbed compounds that cause taste and odor as plant influent concentrations decline. This phenomenon results in higher levels of taste and odor in the plant discharge than at the plant influent, and is sometimes problematic for facilities that utilize fixed-bed granular activated carbon (GAC) filtration processes.

b. Powdered Activated Carbon Contact Basin at Plant Headworks

Another potential approach to enhance the use of PAC for taste and odor control would be to construct a baffled, mechanically-mixed PAC contact basin upstream of the existing rapid mix chambers. The energy imparted to the water by multiple vertical-shaft turbine-type mixers would maintain the PAC in suspension, thereby ensuring effective contact with the process stream and maximizing potential for adsorption of organic compounds. A theoretical hydraulic detention time of approximately 20 to 30 minutes would assist in achieving maximum PAC utilization prior to addition of alum or other coagulants in the downstream rapid mix chambers. Serpentine-type baffling would be provided to minimize short-circuiting of flow through the basin.

To ensure ability to provide effective control of taste and odor compounds, current maximum PAC dosage capability would need to be increased to 30 to 50 mg/L. Therefore, additional PAC slurry metering pump capacity would need to be added to provide expanded dosage capabilities.

Feasibility of this approach with respect to taste and odor control can be readily evaluated through bench-scale testing during a period when taste and odor-causing compounds are present in the source water at relatively high levels, and would be recommended prior to any decision to construct full-scale PAC contact facilities at the Monroe WTP.

5. TREATMENT TECHNOLOGIES

c. Granular Activated Carbon Filter Adsorbers

An approach to adsorption of taste and odor compounds which has been successful at some utilities involves replacement of all or part of the existing filter media with GAC. In addition to providing the capability to remove taste and odor-causing compounds by adsorption, GAC is also an excellent filter medium for removal of turbidity and suspended solids. GAC depth and hydraulic loading rate determine the empty bed contact time (EBCT), the key design parameter for GAC adsorption systems. However, the ability of GAC to remove some taste and odor-causing compounds, such as geosmin and methylisoborneol (MIB), is site-specific and highly dependent on availability of adequate carbon contact times. At the Monroe WTP, the available GAC contact time would be less than 4 minutes at current plant design flow rates if the existing anthracite were to be replaced with GAC. Therefore, filter-adsorbers may not be effective in all cases for taste/odor control at the relatively short EBCTs typically provided. The GAC media must also be replaced periodically to maintain ability to adsorb taste and odor compounds; experience at other utilities suggests that required GAC replacement intervals are typically 18 to 24 months. Desorption of previously-adsorbed taste and odor compounds when source water concentrations decline can also be problematic for filter adsorbers.

d. Post-Filter Granular Activated Carbon Adsorbers

Separate GAC adsorption units following filtration offer the most flexibility in designing and operating a system to achieve specific adsorption objectives, as they can provide longer EBCT than filter adsorbers, and thus can achieve more efficient removal of taste and odor-causing compounds. Unlike filter adsorbers, post-filter GAC contactors do not require frequent backwashing. Backwashing is generally avoided, as it disrupts the adsorption front (mass transfer zone) in the bed, and may cause premature breakthrough. Use of post-filter GAC adsorbers may also allow the utility to be granted an additional 0.5-log *Cryptosporidium* removal credit (“second stage filtration”) under the pending LT2ESWTR.

5. TREATMENT TECHNOLOGIES

However, construction costs for post-filter GAC adsorption facilities would be considerably higher than for other taste/odor control options.

A summary of the advantages and disadvantages of the candidate technologies is presented below.

Pretreatment

<u>Conventional / "Enhanced" Conventional</u>

Principle:

- Gravity sedimentation (with or without tubes)

Advantages:

- CUD familiarity with process
- IDEM approval without additional testing

Disadvantages:

- Large footprint area
- Process efficiency reduced as water temperatures decline

<u>Inclined Plate Sedimentation</u>

Principle:

- Sedimentation, large effective surface area

Advantages:

- Significant reductions in footprint area vs. conventional
- High degree of hydraulic uniformity

Disadvantages:

- Very dependent upon effective flocculation, uniform floc size
- Requires deeper basins than conventional sedimentation

5. TREATMENT TECHNOLOGIES

Dissolved Air Flotation

Principle:

- Solids buoyed to surface by attachment to microbubbles

Advantages:

- Small footprint area required
- Very effective for removal of algae, color, light floc particles

Disadvantages:

- High energy costs

Ballasted Clarification

Principle:

- "Anchoring" of floc particles to microsand to achieve high settling rates

Advantages:

- Small footprint area required
- Very effective for removal of algae
- Adaptability to rapid changes in raw water quality

Disadvantages:

- Short process hydraulic detention times
- Heavy dependence on polymer
- Proprietary process eliminates competitive bidding

Sludge Blanket Clarifiers (Superpulsator®)

Principle:

- Sedimentation, solids capture by enmeshment in blanket

Advantages:

- More forgiving of non-uniform floc sizes
- Minimal equipment; no moving parts below water surface

Disadvantages:

- Subject to thermal and hydraulic upsets
- Extended startup period required while blanket is formed

5. TREATMENT TECHNOLOGIES

Filtration

Granular Media Filters

Principle:

- Adsorption of particles on media grains (collector sites)

Advantages:

- Can serve multiple concurrent purposes:
  - Solids capture/removal
  - Manganese adsorption
  - Support media for biological activity

Disadvantages:

- Very dependent upon "optimal" chemical pretreatment

MF / UF Membranes

Principle:

- Physical straining

Advantages:

- High removal efficiency independent of feed water quality
- Modular; can expand capacity incrementally

Disadvantages:

- Removes particulate matter only
- Attention to cleaning frequency and regime critical to sustaining flux rates

5. TREATMENT TECHNOLOGIES

Disinfection

Chlorine / Chloramines

Principle:

- Chemical inactivation

Advantages:

- Low operating and chemical costs
- Operator familiarity with process

Disadvantages:

- Forms regulated DBPs (TTHMs, HAA5)
- Does not inactivate *Cryptosporidium*
- Potential safety issue associated with release of gaseous chlorine

Chlorine Dioxide

Principle:

- Chemical inactivation

Advantages:

- Effective for inactivation of *Giardia* and viruses
- Does not form TTHMs or HAA5

Disadvantages:

- Dosage limited by chlorite MCL
- Minimally effective for inactivation of *Cryptosporidium*
- Potential odor problems in distribution if free chlorine used for residual maintenance

Ozone

Principle:

- Chemical inactivation

Advantages:

- Very effective for inactivation of *Giardia* and viruses
- Effective for *Cryptosporidium* in waters > 5° C
- Also effective for taste and odor control

Disadvantages:

- May form bromate if bromide present in source water
- Marginally effective for *Cryptosporidium* under cold water conditions

Ultraviolet Irradiation

Principle:

- Chemical inactivation

Advantages:

- Very effective for inactivation of *Giardia* and *Cryptosporidium*
- Does not create regulated DBPs

Disadvantages:

- Marginally effective for inactivation of viruses
- May be difficult to retrofit in some cases

Taste and Odor Control

Powdered Activated Carbon

Principle:

- Adsorption

Advantages:

- High adsorptive affinity for taste and odor compounds
- Can be fed only as needed/when required
- Relatively low initial feed system costs
- No desorption of previously-removed compounds

Disadvantages:

- Interaction with coagulants reduces effectiveness
- Mixing required to maintain PAC in suspension
- High dosages may be required to handle severe taste and odor

5. TREATMENT TECHNOLOGIES

Granular Activated Carbon Filter Adsorbers

Principle:

- Adsorption (fixed bed)

Advantages:

- GAC provides excellent filter medium
- Construction of new facilities not required

Disadvantages:

- Available media depths limit contact times
- Periodic removal/replacement of GAC is labor-intensive
- Potential for desorption of taste and odor compounds as influent concentrations decline

Post Filter Granular Activated Carbon

Principle:

- Adsorption (fixed bed)

Advantages:

- Very effective for removal of taste and odor compounds
- Reduces chlorine demand
- Potential 0.5-log additional *Cryptosporidium* removal credit

Disadvantages:

- High initial construction costs

D. CONSIDERATIONS FOR NEW TREATMENT FACILITIES

1. General Treatment Considerations

The conventional clarification/filtration process used at the existing Monroe WTP has demonstrated the ability to effectively treat water from Lake Monroe to produce finished water that meets both current and anticipated future water quality and treatment requirements. A possible exception would be the potential future need to achieve higher levels of *Cryptosporidium* removal/inactivation under the pending LT2ESWTR, based on results of recently-initiated source water monitoring. Therefore, with careful operation, any of the various pretreatment and filtration technologies discussed above would be capable of treating water from Lake Monroe to yield finished water that meets regulatory requirements and CUD's internal water quality goals.

Review of recent water quality data for Lake Monroe and assessment of current treatment requirements suggests that high color levels and/or algae counts that may negatively impact filter performance are not typically experienced at the Monroe WTP. Therefore, use of DAF treatment is not considered necessary or cost-effective for this water. Applicability of Superpulsator® clarifiers to treat Lake Monroe water cannot be readily determined without conducting site-specific pilot testing. However, based on experience at other locations in treating relatively low-turbidity supplies, concerns related to impact of changes in flow rates and/or influent water temperatures on clarifier performance and potential extended startup time requirements following removal of a basin from service, Superpulsator® clarifiers would not be recommended. Other high-rate clarification processes (inclined plates, ballasted clarification) would be capable of providing cost-effective treatment of Lake Monroe water.

As manganese is present in the Lake Monroe source water at levels that would result in consumer complaints if not removed during treatment, the ability to effectively remove manganese is a critical issue in the selection of the most appropriate treatment process for expansion of production capacity. The ability of the existing granular media filters to effectively remove manganese through catalytic precipitation and/or adsorption onto previously deposited manganese oxides on the filter media has also been well documented.

Pilot-scale testing of both submerged and encased membranes at the Monroe WTP during 2001 and 2002 demonstrated that membrane filtration would be a viable alternative to conventional granular media filtration. However, provisions for removal of dissolved organic compounds by chemical coagulation prior to membrane treatment would be recommended to ensure compliance with more restrictive DBP requirements at individual system monitoring locations under the pending Stage 2 DBPR. Coagulation, flocculation, and sedimentation prior to membrane filtration would be recommended to maximize removal of DBP precursor compounds, and would facilitate use of higher design membrane flux rates, thereby reducing required membrane area and system costs.

Many water utilities that rely on surface water sources are taking preemptive measures to ensure the continued safety of their customers with respect to exposure to chlorine-resistant pathogens such as *Cryptosporidium*. One of these measures is the installation of UV disinfection. Because of the relatively high benefit-to-cost ratio, many utilities have come to view UV disinfection as good insurance against potential outbreaks of waterborne disease, and CUD may want to consider installation of UV disinfection facilities regardless of the outcome of source water monitoring currently being conducted to satisfy LT2ESWTR requirements.

2. Expansion of Monroe Water Treatment Plant

Based on the above considerations, high rate clarification using inclined plates, followed by granular media filtration and UV disinfection is considered the most cost-effective treatment process configuration to expand production capacity at the Monroe WTP and to assure compliance with potential future regulatory requirements. Reductions in required basin sizes associated with the inclined plate sedimentation process may yield savings in initial construction costs, and overall operating costs would be lower than for other high-rate pretreatment processes. From an operator familiarity and operational requirements standpoint, inclined plate sedimentation is the unit process most similar to the current conventional flocculation/sedimentation process at the Monroe WTP, and process residuals would be essentially identical in composition and consistency to those for the existing treatment process.

5. TREATMENT TECHNOLOGIES

Post-filtration UV disinfection would provide an additional barrier to microbial pathogens within the treatment process. Retrofitting of the existing granular media filters with microfiltration or ultrafiltration membranes to maximize ability to remove *Cryptosporidium* would be significantly more costly than UV, and would eliminate the capability to convert the existing filters to GAC adsorbers for control of tastes and odors. Also, considering the low water temperatures typically experienced at the Monroe WTP during the winter months, the use of ozonation for inactivation of *Cryptosporidium* would not be cost-effective due to the high residual and contact times required.

Addition of chlorine at the Monroe WTP influent as a preoxidant and to achieve compliance with disinfection contact time (CT) requirements within the existing flocculation/sedimentation basins, followed by addition of ammonia to form chloramines, has been effective in maintaining compliance with current DBP requirements. However, in order to maximize ability to maintain low DBP concentrations in the finished water thus ensuring compliance with more stringent requirements under the pending Stage 2 DBPR, CUD may want to consider shifting the point of initial chlorine addition to the filter influent. Provisions for feeding chlorine dioxide at low dosages at the plant influent as necessary to control algae/nuisance organism accumulations within the flocculation/sedimentation basins should be considered if modifications to current chlorine feed practices are implemented. Continued use of chloramines to limit DBP formation and to provide a stable disinfectant residual within the distribution system is recommended.

Improved ability to control undesirable tastes and odors can be achieved by increasing maximum PAC feed dosage capability through either:

- Modifications to allow PAC slurry to be fed into the raw water pipeline well upstream of the rapid mix chamber
- Construction of a new mechanically-mixed PAC contact basin upstream of the existing plant headworks.

5. TREATMENT TECHNOLOGIES

These modifications would maximize PAC's ability to adsorb taste/odor compounds by eliminating interferences associated with simultaneous addition of PAC and coagulant/chlorine in the primary rapid mix. While post-filter GAC contactors would be effective in controlling taste and odor, they would also be considerably more expensive than other PAC-based options.

3. New Surface Water Treatment Plant

Based on our knowledge of the current Lake Monroe supply and associated treatment requirements, the following unit treatment process configuration would be recommended for a new WTP at a different site:

- Addition of PAC for taste/odor control at the raw water intake or in the raw water pipeline upstream of the treatment facilities.
- High-rate clarification, consisting of either:
    - An Actiflo® ballasted clarification process
    - Conventional flocculation and sedimentation basins equipped with inclined plate settling equipment.
- MF or UF membrane filtration.
- Post MF/UF disinfection with chlorine as the primary disinfectant, followed by conversion of the free chlorine residual to chloramines for residual maintenance within the distribution system.

6. REVIEW OF WATER SYSTEM ALTERNATIVES

The primary responsibility of a domestic water purveyor is to provide its customers with a plentiful supply of high quality water. While meeting this primary responsibility, the purveyor also is expected to provide satisfactory service and operate the water system in a financially responsible manner. Within the water industry, it is generally accepted that distribution facilities should be designed to provide an acceptable degree of reliability. The facilities also must maintain adequate pressures throughout the system while supplying maximum hour (MH) water use and a reasonable amount of water for fire fighting.

It is a recommended water utilities practice to provide water supply and treatment facilities with sufficient capacity to meet projected maximum day (MD) demands. Section 3 - Water Requirements Review indicated the MD demands could reach approximately 24 million gallons per day (mgd) by Year 2010. The current rated capacity of the existing Monroe Water Treatment Plant (WTP) is 24 mgd.

Three treatment expansion alternatives were evaluated in the Long Range Water Capital Plan (LRWCP) to provide sufficient firm capacity to meet projected maximum day demands. The three plans that were identified and evaluated were as follows:

- Alternative A – Expand the Monroe WTP from 24 to 36 mgd
- Alternative B – Construct a new 12 mgd Dillman WTP
- Alternative C – Construct a new 12 mgd North WTP

Additionally as an option to Alternative A, expansion of the Monroe WTP from 24 to 30 mgd was evaluated to compare the costs of a phased expansion of the Monroe WTP in 6 mgd increments. The 6 mgd expansion from 24 to 30 mgd is expected to serve the needs of Bloomington and Monroe County through 2025 as noted in Section 3 - Water Requirements Review. Two options were also considered for Alternative C which included different water sources and treatment technologies. The option to Alternative C, which included Lake Lemon, Bean Blossom Creek and Griffy Lake as an Alternative water supply, is no

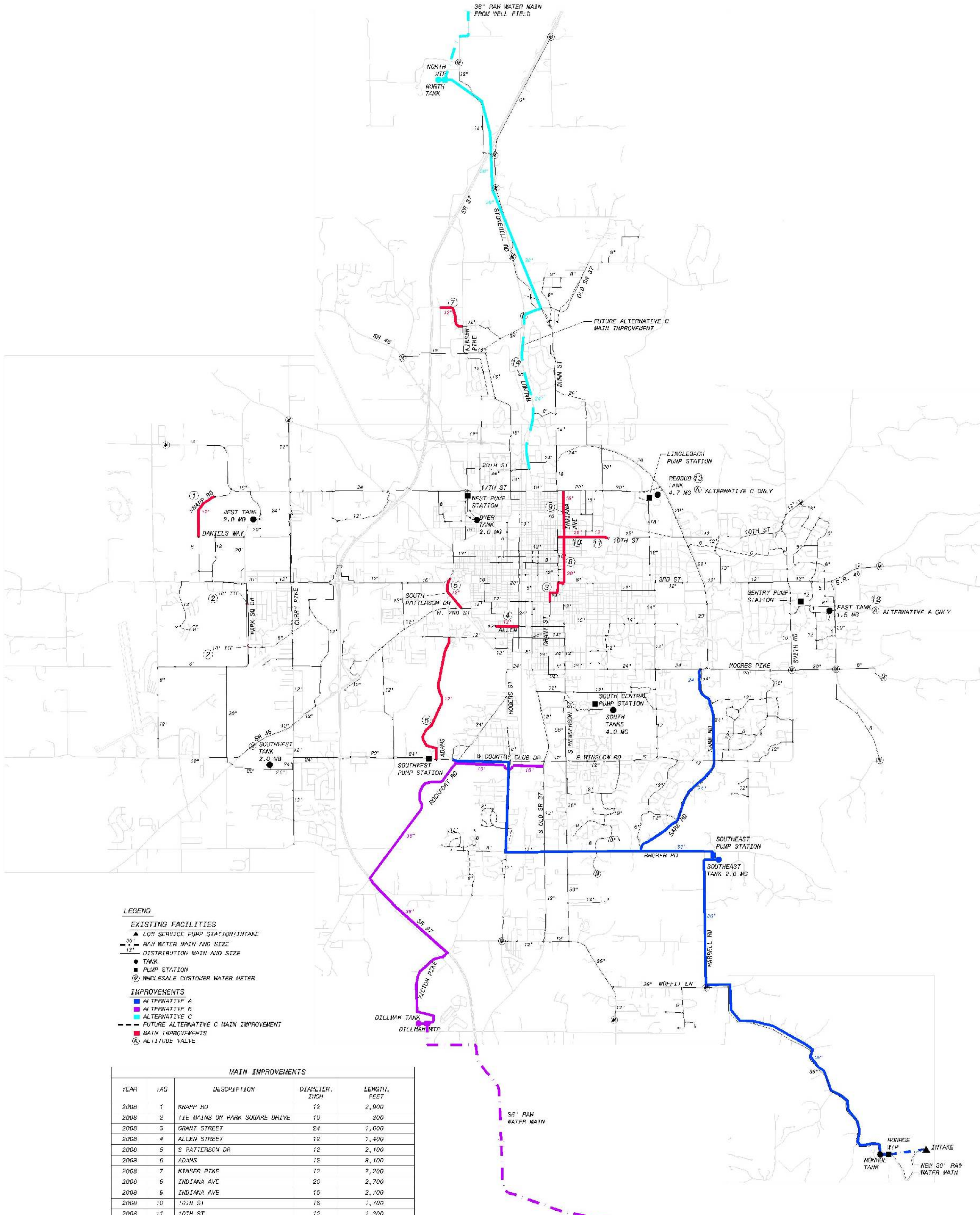
6. REVIEW OF WATER SYSTEM ALTERNATIVES

longer being considered due to concerns of the safe yield of the water supplies and raw water quality concerns by the City of Bloomington Utilities Department (CUD). The safe yield of these water supplies is 6 mgd combined. Figure 6-1 provides an overview of the distribution system and the three main alternatives. All of the plans are feasible from an engineering standpoint and will meet CUD's projected short-term and long-term water requirements.

A. REVIEW OF ALTERNATIVE PLANS

As presented in the LRWCP, to meet future water requirements, CUD will need to either expand the Monroe WTP (Alternative A) or construct either a new Dillman (Alternative B) or North (Alternative C) WTP. From an economic standpoint, it is more favorable to expand the Monroe WTP, however, from a reliability standpoint, constructing the Dillman or North facility would be preferable. From a hydraulic standpoint, Alternative C provides the benefit of serving customers from the north.

The following is a review of the improvements required for each alternative. The review is based on current water treatment technology recommendations for a new water treatment plant and expansion of the Monroe WTP as discussed in Section 5 - Treatment Technologies. For a new water treatment plant, membrane filtration is recommended and reverse osmosis (RO) for softening is recommended at the North WTP. However, for expansion of the Monroe WTP, conventional filtration followed by Ultraviolet (UV) disinfection is recommended because the Monroe WTP is presently in compliance with finished water turbidity requirements. It was recommended in the LRWCP that CUD consider continuing the use of conventional filtration followed by UV disinfection at the Monroe WTP for *Cryptosporidium* inactivation. Also as indicated in the LRWCP, conventional filtration and UV disinfection would likely be less costly than membrane filtration and continue to provide high quality water to CUD customers.



LEGEND

EXISTING FACILITIES
- ▲ LOW SERVICE PUMP STATION/INTAKE
- RAW WATER MAIN AND SIZE
- DISTRIBUTION MAIN AND SIZE
- ● TANK
- ■ PUMP STATION
- Ⓦ WHOLESALE CUSTOMER WATER METER

IMPROVEMENTS
- ALTERNATIVE A
- ALTERNATIVE B
- ALTERNATIVE C
- FUTURE ALTERNATIVE C MAIN IMPROVEMENT
- MAIN IMPROVEMENTS
- Ⓐ ALTITUDE VALVE

MAIN IMPROVEMENTS

YEAR	TAG	DESCRIPTION	DIAMETER, INCH	LENGTH, FEET
2008	1	KNAPP RD	12	2,900
2008	2	TIE MAINS ON PARK SQUARE DRIVE	10	300
2008	3	GRANT STREET	24	1,600
2008	4	ALLEN STREET	12	1,400
2008	5	S PATTERSON DR	12	2,100
2008	6	ADAMS	12	8,100
2008	7	KINSER PIKE	12	2,200
2008	8	INDIANA AVE	20	2,700
2008	9	INDIANA AVE	16	2,700
2008	10	10TH ST	16	1,700
2008	11	10TH ST	12	1,300
2008	12	EAST TANK ALTITUDE VALVE	20	-
2008	13	REDBUD TANK ALTITUDE VALVE	20	-
2008	14	WALNUT ST	24	10,200

CITY OF BLOOMINGTON UTILITIES DEPARTMENT

WATER SUPPLY EVALUATION

WATER SYSTEM ALTERNATIVES

BLACK & VEATCH Corporation
Indianapolis, Indiana

DESIGNED: ALB
DETAILED: RSF, BLH
CHECKED:
APPROVED:
DATE:

PROJECT NO.
146258

FIGURE 6-1

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
STORET ID: 146258-1000-C-T0060WRST	XREF1 ID:				
SAVED: DUN38005, 5/28/2007 2:58:27 PM	XREF2 ID:				
DWG VER #: 1.2	XREF3 ID:				
PLOTTED: FLA36005, 8/29/2007 1:25:02 PM	XREF4 ID:				
USER: DUN38005	SM: Figure 6-1.dwg XREF5 ID:				

FDS000
05074

6. REVIEW OF WATER SYSTEM ALTERNATIVES

This review includes an update of the opinion of probable costs and advantages and disadvantages. Each of the alternatives discussed below would require the rehabilitation of the existing filters and filter valves at the Monroe WTP. Therefore, the costs of this rehabilitation project have not been included as the project is currently funded.

1. Alternative A – Expand Monroe Water Treatment Plant from 24 to 36 mgd

Alternative A includes expanding the 24 mgd Monroe WTP to a capacity of 36 mgd. This alternative would require a parallel 30-inch raw water line to be installed from the intake to the plant and a parallel 36-inch finished water transmission main from the plant to Harrell Road and Moffat Lane. The proposed 36-inch finished water transmission main would connect to the existing 36-inch transmission main near the intersection of Harrell Road and Moffat Lane and the new main would continue north along Harrell Road as a 30-inch main. This alternative includes a new Southeast Pump Station and Tank located near Harrell and Rhorer Roads; a 36-inch main along Rhorer to Sare Road; and a 24-inch North branch main along Sare Road to the existing 24-inch main in Moores Pike. The 24-inch West branch main is required to reinforce the western portion of the Central Zone and will be completed by CUD as a separate project. Therefore, the West branch is not included in the costs for Alternative A. The West branch continues west along Rhorer Road, then north along South Rogers Street to West Country Club Drive, then west along Country Club Drive to connect to the two existing 24-inch mains at the intersection of Rockport and West Tapp Roads. Based on review of the water treatment technologies in Section 5 - Treatment Technologies, this option would include high rate clarification using inclined plates, followed by granular media filtration. Installation of UV disinfection is recommended as an additional disinfection barrier. The cost for UV disinfection is shown as an alternative cost in Section 8 - Opinion of Probable Costs.

6. REVIEW OF WATER SYSTEM ALTERNATIVES

a. Advantages

- The proposed transmission main will provide redundancy to the existing 36-inch transmission main from the Monroe WTP to the existing South tanks.
- If a break should occur in one of the two finished water transmission mains (existing or proposed), CUD can continue to provide up to 24 mgd to the distribution system where the other alternatives would only provide up to 12 mgd to the distribution system.
- The proposed Southeast Pump Station would provide water to the Central service level if the South-Central Pump Station is off-line or if there is a break in the existing 36-inch transmission main serving the South-Central Pump Station.
- Lake Monroe is used, which has an abundant supply of good quality raw water.
- There is familiarity with the water supply.
- Expanding the Monroe WTP is the most economical of the three alternatives.

b. Disadvantages

- Does not provide an independent second water source.
- It is currently unknown if the Monroe WTP can be easily expanded past 36 mgd.

2. Option to Alternative A – Expand Monroe Water Treatment Plant from 24 to 30 mgd

Option to Alternative A includes expanding the 24 mgd Monroe WTP to a capacity of 30 mgd. This option was developed as the Monroe WTP was originally designed to be easily expanded in 6 mgd increments. Increasing the capacity from 24 to 30 mgd would allow CUD to build the facilities necessary to serve their customers through 2025. In addition, CUD may decide to implement conservation measures which may delay the need for future improvements beyond 2025. The distribution system improvements and water treatment technologies for this alternative would be the same as Alternative A. The high rate clarification basin would be sized for 12 mgd capacity to match the capacity of the existing basins. In addition, piping and electrical systems for this alternative will accommodate a future capacity of 36 mgd.

a. Advantages

- The proposed transmission main will provide redundancy to the existing 36-inch transmission main from the Monroe WTP to the existing South tanks.
- If a break should occur in one of the two finished water transmission mains (existing or proposed), CUD can continue to provide up to 24 mgd to the distribution system where the other alternatives would only provide up to 12 mgd to the distribution system.
- The proposed Southeast Pump Station would provide water to the Central service level if the South-Central Pump Station is off-line or if there is a break in the existing 36-inch transmission main serving the South-Central Pump Station.
- Lake Monroe is used, which has an abundant supply of good quality raw water.
- There is familiarity with the water supply.
- Expanding the Monroe WTP is the most economical of the three alternatives.
- Lower initial construction cost by constructing the facilities necessary to serve CUD customers through 2025.

6. REVIEW OF WATER SYSTEM ALTERNATIVES

b. Disadvantages

- Does not provide an independent second water source.
- A phased plant expansion in 6 mgd increments is more costly than expanding to 36 mgd in a single project phase.

3. Alternative B – New 12 mgd Dillman Water Treatment Plant

Alternative B involves constructing a new 12 mgd membrane filtration WTP that is expandable to 24 mgd, adjacent to the Dillman Wastewater Treatment Plant (WWTP), near Dillman Road and Victor Pike. Raw water would be conveyed through a 36-inch transmission main from a new intake located near the Indiana Department of Natural Resources (IDNR) site on Lake Monroe. From the Dillman WTP's high service pumps, finished water would be conveyed through a 36-inch transmission main into two 24-inch Central service level mains at Rockport and Tapp Roads and a 16-inch main along West Country Club Drive between Rockport Road and South Old SR 37. Installation of UV disinfection at the Monroe WTP is also recommended as an additional disinfection barrier and to provide similar high quality water to CUD customers as the Dillman WTP. The cost for UV disinfection is shown as an alternative cost in the Appendix - Opinion of Probable Project Costs.

a. Advantages.

- The intake facility can be expanded easily to a capacity of 24 mgd.
- Residuals can be pumped to the Dillman WWTP for processing, thereby eliminating the need for a residuals dewatering facility.
- Treated water would be pumped directly into the Central service level, thereby eliminating the need for the Fullerton Pump Station and Tank previously proposed by CUD.

6. REVIEW OF WATER SYSTEM ALTERNATIVES

- Provides 12 mgd of treated water to the system in the event that the Monroe WTP or intake is off-line or if there is a break in the existing 36-inch finished water transmission main.
- Having two separate withdrawal locations on Lake Monroe provides a greater level of reliability than with a single intake and treatment facility.
- Lake Monroe is used, which has an abundant supply of quality raw water.
- There is familiarity with the water supply.

b. Disadvantages

- Increases operation and maintenance (O&M) costs by having a second WTP and staff.
- Higher capital cost.

4. Alternative C – New 12 mgd North Water Treatment Plant Using Groundwater Supply with Membrane Filtration

Alternative C involves constructing a new 12 mgd North WTP with membrane filtration that is expandable to 24 mgd, near Bottom Road and State Route 37 or adjacent to the Blucher Poole WWTP. Groundwater from a collector well, located approximately 12 miles north of Bloomington near the confluence of the White River and Bean Blossom Creek, would be conveyed through a 36-inch transmission main to the new plant. The plant would treat the water using membrane filtration for solids removal and reverse osmosis (RO) for softening. If the water supply to the North is considered to be strictly groundwater, using microfiltration/ultrafiltration (MF/UF) membranes prior to RO membranes would not be recommended from an economical standpoint; oxidation of any iron and manganese followed by conventional gravity media filters would be recommended in lieu of the MF/UF membranes. From the new North WTP, finished water would be conveyed through a 36-inch transmission main to the Central service level mains near Stonemill Road and Old State Route 37. If the North WTP is expanded to 24 mgd, then the 36-inch main should be extended as

6. REVIEW OF WATER SYSTEM ALTERNATIVES

a 24-inch main along Walnut Street to the existing 24-inch main on 20th Street. Installation of UV disinfection at the Monroe WTP is also recommended as an additional disinfection barrier and to provide similar high quality water to CUD customers as the North Plant. The cost for UV disinfection is shown as an alternative cost in the Appendix - Opinion of Probable Project Costs.

a. Advantages

- The water supply is independent of Lake Monroe, and provides a greater level of reliability as compared to a single supply and treatment facility.
- Provides 12 mgd of treated water to the system in the event that the Monroe WTP or intake is off-line or if there is a break in the existing 36-inch finished water transmission main.
- Less pumping head is required to convey water to the northern extremities of the distribution system from the proposed North WTP than from the existing Monroe or proposed Dillman WTP.
- Residuals can be pumped to the Blucher Poole WWTP for processing, thereby eliminating the need for a residuals dewatering facility.

b. Disadvantages

- Increases O&M costs by having a second WTP and staff.
- Requires a new collector well and associated piping to expand the WTP to 24 mgd.
- Has water quality compatibility concerns related to the mix of treated surface water and groundwater.
- High capital cost.

6. REVIEW OF WATER SYSTEM ALTERNATIVES

5. Option to Alternative C – New 12 mgd North Water Treatment Plant Using Groundwater Supply with Gravity Media Filtration

Option to Alternative C involves constructing a new 12 mgd North WTP with gravity media filtration that is expandable to 24 mgd, near Bottom Road and State Route 37 or adjacent to the Blucher Poole WWTP. Groundwater from a collector well, located approximately 12 miles north of Bloomington near the confluence of the White River and Bean Blossom Creek, would be conveyed through a 36-inch transmission main to the new plant. The plant would treat the water using gravity media filtration for solids removal and reverse osmosis (RO) for softening. From the new North WTP, finished water would be conveyed through a 36-inch transmission main to the Central service level mains near Stonemill Road and Old State Route 37. If the North WTP is expanded to 24 mgd, then the 36-inch main should be extended as a 24-inch main along Walnut Street to the existing 24-inch main on 20th Street. Installation of UV disinfection at the Monroe WTP is also recommended as an additional disinfection barrier and to provide similar high quality water to CUD customers as the North Plant. The cost for UV disinfection is shown as an alternative cost in the Appendix - Opinion of Probable Project Costs.

a. Advantages

- The water supply is independent of Lake Monroe, and provides a greater level of reliability as compared to a single supply and treatment facility.
- Provides 12 mgd of treated water to the system in the event that the Monroe WTP or intake is off-line or if there is a break in the existing 36-inch finished water transmission main.
- Less pumping head is required to convey water to the northern extremities of the distribution system from the proposed North WTP than from the existing Monroe or proposed Dillman WTP.
- Residuals can be pumped to the Blucher Poole WWTP for processing, thereby eliminating the need for a residuals dewatering facility.

6. REVIEW OF WATER SYSTEM ALTERNATIVES

b. Disadvantages

- Increases O&M costs by having a second WTP and staff.
- Requires a new collector well and associated piping to expand the WTP to 24 mgd.
- Has water quality compatibility concerns related to the mix of treated surface water and groundwater.
- High capital cost.

The costs presented in Table 6-1 reflect January 2007 price levels and the water treatment technologies recommended herein. The costs presented include Total Probable Construction Cost and includes 20 percent for contingencies; and Total Probable Project Cost Plus Debt Issuance Cost. Also included is the Projected 2008 Additional Rate Increase for each Alternative.

An allowance has been included for engineering, construction administration, resident engineering, SCADA configuration, surveying and subsurface investigations. Land and easement acquisition has been included. The costs do not include legal, financial consulting, CUD staff salaries, expenses to the project or unusual construction conditions. Detailed costs for each Alternative are presented in the Appendix.

6. REVIEW OF WATER SYSTEM ALTERNATIVES

Table 6-1
Alternatives Cost Comparison

Alternative	Total Probable Construction Cost	Total Probable Project Cost Plus Debt Issuance Cost	Projected 2008 Additional Rate Increase
Alternative A Expand the existing Monroe WTP from 24 to 36 mgd using gravity media filtration.	$36,600,000	$48,395,000	53%
Option to Alternative A Expand the existing Monroe WTP from 24 to 30 mgd using gravity media filtration.	$32,400,000	$42,120,000	46%
Alternative B New 12 mgd Dillman WTP with Lake Monroe supply using membrane filtration.	$61,100,000	$82,270,000	91%
Alternative C New 12 mgd North WTP with groundwater supply using membrane filtration and reverse osmosis for softening.	$75,700,000	$102,315,000	113%
Option to Alternative C New 12 mgd North WTP with groundwater supply using gravity media filtration and reverse osmosis for softening.	$70,300,000	$95,175,000	105%

Notes
1. Probable Construction Costs are based on January 2007 price levels.
2. Debt Issuance Costs and Projected Rate Increase were provided by Crowe Chizek and Company LLC.
3. Total Probable Project Cost Plus Debt Issuance Cost includes Construction, Engineering, Land and Easement Acquisition, Debt Issuance Cost, and 6% Annual Inflation Factor.
3. UV Disinfection Alternative Costs are not included in the above costs.
4. Assumes one 20-year Competitive Bond Issue for all Alternatives.
5. Annual Extensions and Replacements have been set at a minimum of 30% coverage in each Alternative.

6. REVIEW OF WATER SYSTEM ALTERNATIVES

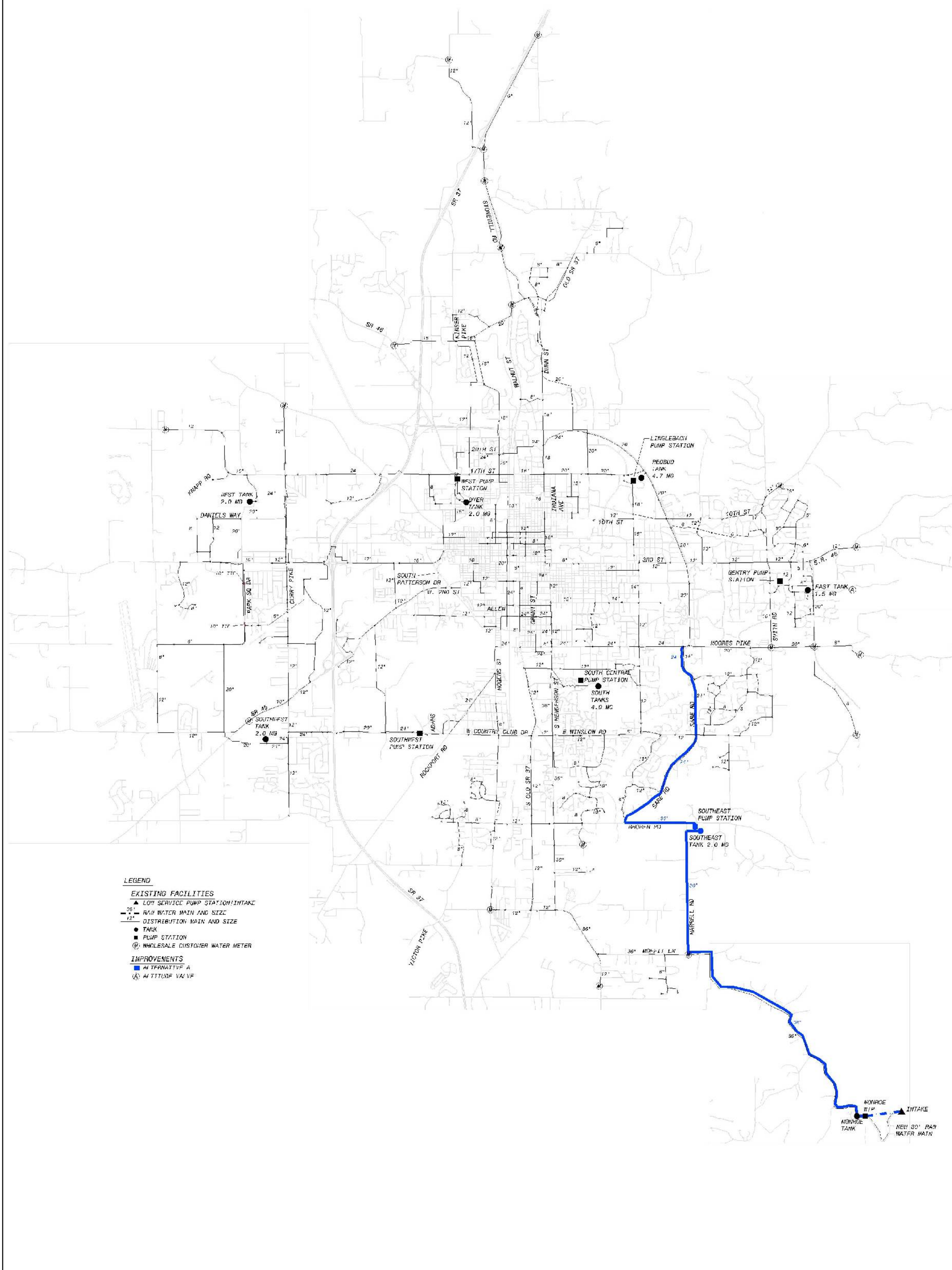
B. MONROE WATER TREATMENT PLANT TRANSMISSION MAIN CONDITION ASSESSMENT

In February 2005, Price Brothers Company completed an inspection of the 36-inch raw and finished prestressed concrete cylinder pipe. The *36" LCP Lake Monroe Transmission Main Condition Assessment Project Final Report* concluded that based on the examinations made and testing performed, the pipelines are in overall excellent condition.

C. RECOMMENDED ALTERNATIVE

The Monroe WTP was originally designed in 1965 to be easily expanded to 36 mgd. A major rehabilitation project at the Monroe WTP was recently completed in 2006. The rehabilitation included replacement of equipment, repair of basins and piping, a new chemical building, a new maintenance building and a new plant-wide SCADA system. In addition, the new chemical building was designed for treatment of 36 mgd. Therefore, the Monroe WTP can be easily expanded to 36 mgd with the appropriate improvements. The Monroe WTP may be expandable to 42 mgd or even 48 mgd; however, additional evaluation would be required to determine the feasibility and the necessary improvements.

Based on the review of the alternatives, it is recommended that CUD proceed with Alternative A and the option to expand the existing Monroe WTP from 24 to 30 mgd. Figure 6-2 provides an overview of the recommended distribution system improvements for this recommendation. This alternative was selected based on several factors including comparison of the capital and operation and maintenance (O&M) costs and advantages and disadvantages. Alternative A has the lowest capital and O&M costs of the alternatives evaluated. Expanding the Monroe WTP does not provide the same level of reliability as having a second water supply or WTP, although with the appropriate measures, a reasonable level of reliability can be achieved. The second 36-inch finished



CITY OF BLOOMINGTON UTILITIES DEPARTMENT

WATER SUPPLY EVALUATION

RECOMMENDED DISTRIBUTION SYSTEM IMPROVEMENTS

BLACK & VEATCH Corporation
Indianapolis, Indiana

DESIGNED: WHA
DETAILED: RSF, BLH
CHECKED:
APPROVED:
DATE:

PROJECT NO.
146258

FIGURE
6-2

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP

CYDNET ID: 146258-1000-C-T0000WRS2	XREF: ID:
SAVED: DUN96005, 5/14/2007 2:42:24 PM	XREF: ID:
DWG VER #: 1.2	XREF: ID:
PLOTTED: FLA36005, 8/29/2007 1:34:10 PM	XREF: ID:
USER: DUN36005 / SW: Figure 6 2.dwg	XREF: ID:

FD5000
D5074

6. REVIEW OF WATER SYSTEM ALTERNATIVES

water transmission main and Southeast Pump Station address concerns identified in the 2002 Vulnerability Assessment.

The LRWCP included a recommendation with Alternative A to include a 24-inch West branch main along Rhorer Road, then north along South Rogers Street to West Country Club Drive, then west along Country Club Drive to connect to the two existing 24-inch mains at the intersection of Rockport and West Tapp Roads. However, this West branch may not be required with the initial capacity of the Southeast Pump Station of 12 mgd. When the Southeast Pump Station is expanded beyond 12 mgd, it is anticipated the West branch main improvements will be required. A hydraulic model analysis should be performed to verify the adequacy to the western portion of the Central service level with and without the proposed West branch improvements. It should be noted that CUD will be constructing a portion of the West branch main as part of another project and plans to complete the West branch main in the next five years.

7. IMPLEMENTATION PLAN

A. IMPLEMENTATION PLAN FOR ALTERNATIVE A

It is recommended that the construction of the facilities and transmission mains associated with expansion of the Monroe Water Treatment Plant (WTP) (Alternative A) be completed in phases. This phased approach allows the City of Bloomington Utilities Department (CUD) to provide an adequate supply of water to meet the projected demands in a financially responsible manner. It is recommended that the expansion of the Monroe WTP be constructed in three separate phases as follows:

- Phase 1 – Monroe WTP Filter Rehabilitation (Project Underway)
- Phase 2 – Southeast Water System Improvements
- Phase 3 – Monroe WTP Expansion from 24 to 30 mgd

Phase 1 is currently under design development and construction is expected to begin in mid-2007. The project consists of replacing the filter media and filter valves, installation of new controls and wiring, and painting of the Washwater Tank interior. This project is needed because the existing media is between 15 and 28 years old and is in need of replacement to provide effective filtering to continue to meet turbidity requirements. In addition, the filter valves are original 1967 valves and need replacement. The interior coating of the Washwater Tank is the original lead based coating system. The interior coating needs to be completely removed and replaced with a new epoxy coating system.

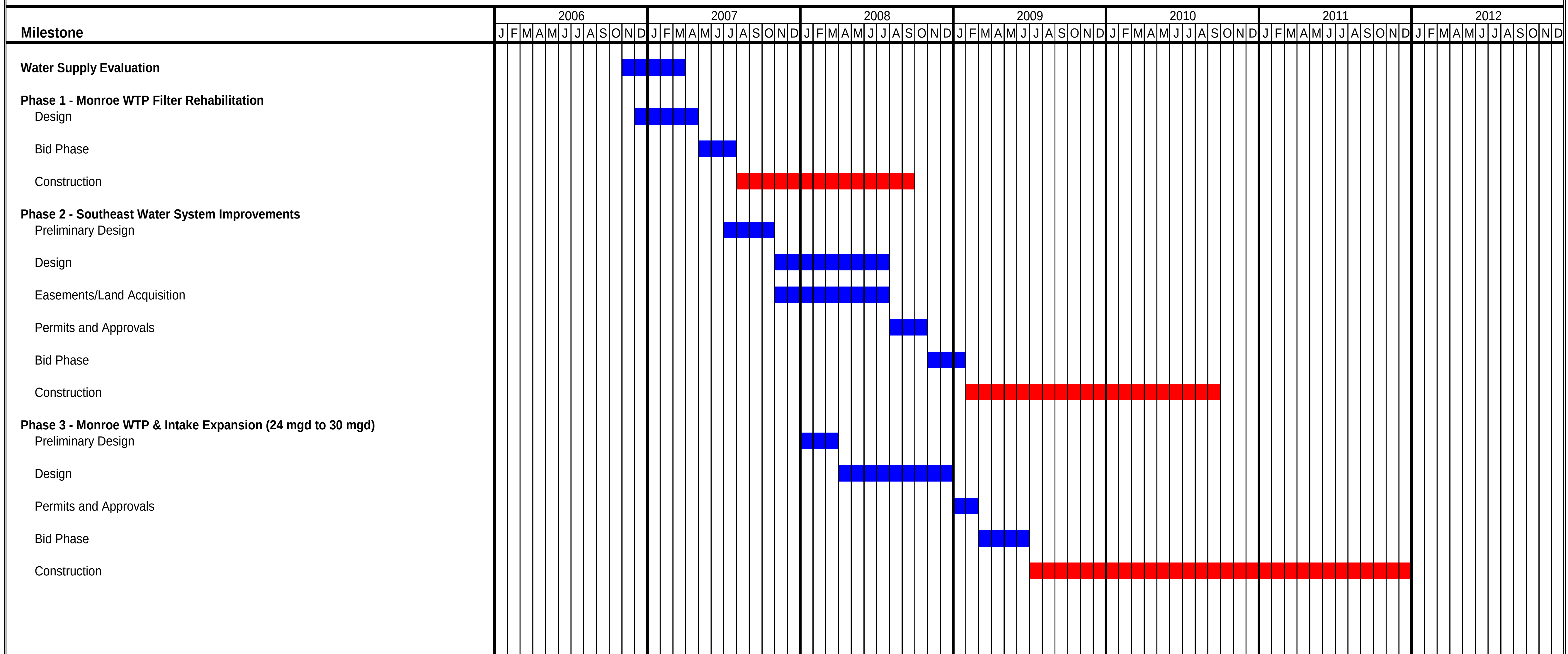
Phase 2 includes approximately 44,000 linear feet (LF) of 36, 30 and 24 inch transmission mains, a 12 million gallons per day (mgd) pump station expandable to 24 mgd and a 2.0 million gallon storage tank. This project is required to convey additional flow from the Monroe WTP and to provide reliability to the distribution system.

Phase 3 includes expansion of the Monroe WTP and Intake Facility to increase the capacity of the plant. The Monroe WTP and Intake Facility will be expanded to 30 mgd and the design will allow easy expansion to 36 mgd in the future. The improvements will include electrical and pumping improvements at the Intake Facility; addition of a flocculation/sedimentation basin; addition of conventional filters; transfer and high service pumping improvements; and electrical upgrades at the plant. Installation of Ultraviolet (UV) disinfection is recommended as an additional disinfection barrier. The cost for UV disinfection is shown as an alternative cost in Section 8 - Opinion of Probable Costs.

The proposed schedule is shown in Figure 7-1. This schedule indicates completion of Phase 2, Southeast Water System Improvements, in 2010 and will provide adequate storage and pumping to meet expected demands. All improvements will be completed in 2011. If required under the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), UV disinfection should be operational by October 2012.

7. IMPLEMENTATION PLAN

Figure 7-1
CITY OF BLOOMINGTON UTILITIES
WATER SUPPLY EVALUATION - SCHEDULE (ALTERNATIVE A)



Notes: 1. Southeast Water System Improvements include a new 2 MG Tank, 12 MGD Pump Station (expandable to 24 MGD) and approximately 44,000 LF of Pipeline.
2. Monroe WTP and Intake Facility Expansion includes Expanding the Capacity of the Intake Facility with the Addition of Pumps, Upgrade of the Electrical Substation at the Plant and Intake and Expanding the Capacity of the Plant using Conventional Filtration with an Alternative for the Installation of UV Disinfection.

8. OPINION OF PROBABLE COSTS

A. PRELIMINARY OPINION OF PROBABLE COSTS

This section presents the preliminary opinion of probable project costs for Alternative A with the option of expanding the Monroe Water Treatment Plant (WTP) to 30 million gallons per day (mgd). All of the construction costs presented herein reflect price levels for January 2007 and include an allowance of 20 percent for contingencies. An allowance has been included for engineering, construction administration, resident engineering, SCADA configuration, surveying, and subsurface investigations. Land and easement acquisition has been included as a separate cost. The costs do not include legal, financial consulting, bond issuance, City of Bloomington Utilities Department (CUD) staff salaries or expenses related to the project or unusual construction conditions other than those specifically identified herein.

As discussed in Section 7 – Implementation Plan, it was recommended that the implementation of Alternative A be constructed in three separate phases. Phase 1 – Monroe WTP Filter Rehabilitation consists of replacing the filter media and filter valves, installation of new controls and wiring and painting of the interior of the Washwater Tank. Phase 2 – Southeast Water System Improvements includes a new 36-inch finished water transmission main to be constructed from the Monroe WTP to Harrell and Moffat Roads and will connect to the existing 36-inch finished water transmission main. A 30-inch finished water transmission main will continue north along Harrell Road to Rhorer Road. A new 12 mgd, expandable to 24 mgd, pump station and 2 million gallon storage tank will be constructed near the intersection of Harrell and Rhorer Roads. From the pump station, a new 36-inch water main will continue west along Rhorer Road to Sare Road. At Sare Road, a 24-inch main will continue north to Moores Pike. A future second 24-inch water main from Sare Road will continue west along Rhorer Road, then north along South Rogers Street to West Country Club Drive, then west along Country Club Drive to connect to two existing 24-inch mains at the intersection of Rockport and West Tapp Roads. The new piping will accommodate the additional flow and provide redundancy to the existing 36-inch finished water piping.

Phase 3 – Monroe WTP Expansion from 24 to 30 mgd will necessitate upgrading the existing Intake Facility to increase the pumping capacity. The existing Intake Facility was designed to accommodate expansion to 36 mgd. The existing pump intake ports are sized to accommodate 36 mgd with a velocity through the ports of less than two feet per second (fps). Modifications to the existing Intake Facility will include removal and replacement of an existing 6 mgd low service pump with a new 12 mgd pump and upgrade of the existing electrical substation. It is assumed that the existing traveling screens are sized adequately to handle the increased flow. The piping and electrical substation improvements will be designed for a future flow of 36 mgd.

A new 30-inch raw water main is recommended to transfer the additional flow from the Monroe Intake Facility to the Monroe WTP. The new raw water piping will connect to the existing 36-inch tee inside the Monroe Intake Facility. Additional valves will be provided, as required for isolation. The length of the new raw water main is approximately 3,000 linear feet (LF).

A preliminary hydraulic profile analysis indicates that the expansion of the Monroe WTP to a capacity of 30 mgd will require construction of one flocculation/sedimentation basin adjacent the existing basins. The new basin will have a rated capacity of 12 mgd to accommodate a future flow of 36 mgd and will be provided with flocculators, circular clarifying equipment, and stainless steel inclined plate sedimentation equipment.

Expansion of the Monroe WTP to a capacity of 30 mgd will require the addition of one or two conventional 6 mgd filters pending approval by the Indiana Department of Environmental Management (IDEM) of filtration rates with one filter out of service. Space is available to the south of the existing Filter Building for the addition of up to three filters in the same configuration as the existing

8. OPINION OF PROBABLE COSTS

filters. The addition of air scouring for the new and existing filters is recommended to provide more efficient cleaning of the media during backwashing, and to reduce required wash water volumes. A filter-to-waste system will also be added to facilitate compliance with more stringent filtered water turbidity requirements.

The firm capacity of the existing Transfer Pump Station will be increased from 24 to 30 mgd. This will include the installation of a 6 mgd pump in one of the open pump slots and associated piping and valve installations. The existing high service pumps have a firm capacity of 24 mgd; therefore, improvements will be required to increase the capacity to 30 mgd. It is anticipated that one new pump and space for two future pumps will be added as part of the Filter Building addition.

The existing chemical feed systems will be upgraded to handle increased chemical dosages associated with the 30 mgd of flow. The upgrades to the existing chemical feed system will include installation of additional equipment, piping, valves, and associated electrical and controls.

The existing electrical substation will be upgraded to accommodate the additional electrical load.

Some preliminary assumptions have been made regarding the construction materials, components, equipment, and processes. These assumptions are discussed below:

<u>Southeast Pump Station</u>

- 12 mgd pump station expandable to 24 mgd
- One engine generator for standby power
- Single story, brick and block building with no basement

8. OPINION OF PROBABLE COSTS

- Concrete foundation
- Three pumping units, each with 6 mgd capacity with space for two future pumps

Southeast Ground Storage Tank

- Two million gallon capacity
- Prestressed concrete construction
- 60 foot side water depth
- 80 foot diameter

Transmission Main

- Prestressed concrete or ductile iron piping
- 3,000 LF of 30-inch raw water main between the Intake Facility and the Monroe WTP
- 17,000 LF of 36-inch piping along Moffat Road between the Monroe WTP and Harrell Road
- 8,000 LF of 30-inch piping along Harrell Road between Moffat and Rhorer Roads
- 4,000 LF of 36-inch piping along Rhorer Road between Harrell and Sare Roads
- 12,000 LF of 24-inch piping along Sare Road between Rhorer Road and Moores Pike
- Valves
- Fire Hydrants
- Air Release Manholes

Existing Monroe Intake Facility

- Remove one 6 mgd pump and replace with a 12 mgd pump
- New piping and valves
- Upgrade electrical substation

8. OPINION OF PROBABLE COSTS

Flocculation/Sedimentation Basin

- One 12 mgd flocculation/sedimentation basin
- Stainless steel lamella plates
- Conventional circular sludge collectors
- Standard vertical flocculators
- Cast-in-place concrete construction

Filter Building

- One or two conventional filters
- Air scour backwash system consisting of two blowers and piping
- Filter-to-waste system

Existing Transfer Pump Station

- Install a new 6 mgd pump in one of the two open pump slots
- Electrical and controls

Existing High Service Pump Station

- Addition of one 6 mgd pump with space for two future pumps
- New adjustable frequency drive
- Electrical and controls

The opinion of probable cost for Alternative A with expansion of the plant from 24 to 30 mgd using conventional filtration is presented in Table 8-1. This cost includes the associated electrical and instrumentation costs. All costs for the facilities and water mains assume rock excavation. In addition, the finished water transmission main cost includes pavement replacement for approximately half of the alignment. The cost for Ultraviolet (UV) disinfection is shown as an alternative cost.

8. OPINION OF PROBABLE COSTS

Table 8-1
Opinion of Probable Costs[1,2]

Phase 1 - Monroe WTP Filter Rehabilitation (Project Underway)	
Total Budgeted Cost (Funded)	**$1,900,000**
Phase 2 - Southeast Water System Improvements	
Pump Station (12 mgd expandable to 24 mgd)	$3,500,000
Ground Storage Tank (2 MG)	$1,600,000
Transmission Mains (44,000 LF)	$9,400,000
Subtotal Construction	$14,500,000
Contingencies (20%)	$2,900,000
Total Construction	$17,400,000
Engineering	$2,700,000
Land and Easement Acquisition	$400,000
Total Probable Cost	**$20,500,000**
Phase 3 - Monroe Water Treatment Plant Expansion	
Intake Facility Pump Upgrade	$300,000
Flocculation/Sedimentation Basin (12 mgd)	$3,000,000
Filter Building (Additional 2 filters)	$3,000,000
Air/Water Backwash System	$1,000,000
Filter-To-Waste System	$400,000
High Service Pump Station (6 mgd)	$1,000,000
Chemical Feed System Improvements	$500,000
Transfer Pump Station Improvements (6 mgd)	$300,000
Electrical Substation Upgrade (Plant and Intake)	$1,000,000
Site Work	$500,000
Miscellaneous	$1,500,000
Subtotal Construction	$12,500,000
Contingencies (20%)	$2,500,000
Total Construction	$15,000,000
Engineering	$3,000,000
Total Probable Cost	**$18,000,000**
Total Probable Project Cost (Phases 2 and 3)	**$38,500,000**
UV Disinfection Alternative	$3,600,000

[1] All costs are based on January 2007 price levels.
[2] Phase 1 costs for the Monroe WTP Filter Rehabilitation are currently budgeted in fiscal year 2007, and are not included in the Total Project Probable Cost.

9. CONCLUSIONS AND RECOMMENDATIONS

The City of Bloomington Utilities Department (CUD) is about to embark on a major capital improvements program to ensure that their customers continue to receive high quality drinking water at sufficient quantities to keep pace with anticipated growth. The Water Supply Evaluation includes a review of population projections and an evaluation of the Lake Monroe water supply and applicable treatment technologies. It also contains a review of the water system alternatives presented in the Long Range Water Capital Plan (LRWCP), including an implementation plan and opinion of probable costs.

A. CONCLUSIONS

Based on information presented in this report, several conclusions were drawn for important components of the project. These conclusions are as follows:

- Population information prepared by the U.S. Census Bureau, Indiana Business Research Center (IBRC) and Black & Veatch (B&V) for the LRWCP was reviewed, compared and updated to reflect revisions since the LRWCP was prepared. The 2030 Long Range Transportation Plan (LRTP) was reviewed, and it was determined that projected population impacts with and without I-69 were minimal.
- Review of water demand projections suggests that maximum day (MD) demands could reach approximately 24 million gallons per day (mgd) by Year 2010. The current rated capacity of the existing Monroe Water Treatment Plant (WTP) is 24 mgd.
- It was determined that Lake Monroe has a sufficient safe yield beyond 2060 based on the water demand projections.
- The firm yield of Lake Monroe was conservatively estimated to be approximately 70 mgd.
- Based upon sedimentation and the United States Army Corps of Engineers (USACE's) latest study for Lake Monroe in October 1999 - *Water Control Manual*, the life of Lake Monroe remains 1966 to 2066. The lake would still be usable well beyond that date, but may require

sediment removal. The USACE has indicated that a study will be performed for a long term solution if sedimentation becomes an issue.

- Review of pending and anticipated future regulatory requirements suggests that there are several water quality/treatment-related parameters that will likely need to be addressed in the design of any future treatment expansion.
- The opinion of probable cost indicates that expanding the capacity of the Monroe WTP is the most economical of the alternatives evaluated (Alternative A). This alternative includes expanding the capacity of the Monroe WTP using conventional filtration; constructing new parallel raw and finished water mains to convey the additional flow to the distribution system; and constructing the Southeast Water System Improvements that will convey the additional treated water from the South service level to the Central service level. The installation of Ultraviolet (UV) disinfection as an additional disinfection barrier and for *Cryptosporidium* inactivation is recommended. The cost for UV disinfection is shown as an alternative cost in Section 8 - Opinion of Probable Costs. This alternative also includes the rehabilitation of the filters at Monroe WTP.
- It was determined that the Monroe WTP could easily be expanded to 36 mgd in the future, as it was originally designed for expansion to 36 mgd.
- The LRWCP included a recommendation with Alternative A to include the 24-inch West branch main with the alternative. When the Southeast pump station is expanded beyond 12 mgd, it is anticipated the West branch main improvements will be required. CUD will be constructing a portion of the West branch main as part of another project and plans to complete the West branch main in the next few years.

B. RECOMMENDATIONS

This section provides a summary of the recommendations presented throughout the report based on the review of the population, water use requirements, water

9. CONCLUSIONS AND RECOMMENDATIONS

supply and alternatives developed during the LRWCP. The recommendations are as follows:

- Based on the population projection comparison between Indiana STATS, B&V and the LRTP, it is recommended to continue the use of the B&V projections as the projections are aligned with Indiana STATS and LRTP.
- Although there are no current concerns with regards to meeting water demands, CUD should evaluate potential water conservation programs. Long-term conservation programs can be practiced by various entities associated with water use including the end users and water suppliers.
- CUD should consider discussions with Indiana Department of Natural Resources (IDNR) to secure the water supply into the future from Lake Monroe as it is a viable and reliable long-term source.
- Based on the review of the alternatives, CUD should proceed with Alternative A and the option to expand the existing Monroe WTP from 24 to 30 mgd. This alternative was selected based on several factors including comparison of the capital and operation and maintenance (O&M) costs; advantages and disadvantages; and implementation requirements and project schedule.
- Since Monroe WTP is presently in compliance with finished water turbidity requirements and given the emergence of UV disinfection in recent years as a viable treatment process for inactivation of *Cryptosporidium*, CUD should proceed with the expansion of the Monroe WTP using conventional filtration followed by UV disinfection as an additional disinfection barrier.
- A hydraulic model analysis should be performed to verify the adequacy to the western portion of the Central service level with and without the proposed West branch improvements.
- The construction of the facilities and transmission mains associated with expansion of the Monroe WTP (Alternative A) should be completed in three separate phases as follows:

9. CONCLUSIONS AND RECOMMENDATIONS

- ✓ Phase 1 – Monroe WTP Filter Rehabilitation (Underway)
- ✓ Phase 2 – Southeast Water System Improvements
- ✓ Phase 3 – Monroe WTP Expansion from 24 to 30 mgd

- Construction of the Phase 2 - Southeast Water System Improvements should be completed in 2010 to provide adequate storage and pumping to meet expected demands.
- The Phase 3 improvements for the Monroe WTP Expansion from 24 to 30 mgd are recommended for completion in 2011.
- If required under the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), UV disinfection should be operational by October 2012.

APPENDIX

Opinion of Probable Project Costs

APPENDIX

Table A-1
Opinion of Probable Project Cost for Alternative A
Expand Monroe WTP from 24 mgd to 36 mgd

Item	Cost[1]
Southeast Water System Improvements	
Pump Station (12 mgd expandable to 24 mgd)	$ 3,500,000
Ground Storage Tank (2 MG)	$ 1,600,000
Transmission Mains (44,000 LF)	$ 9,400,000
Subtotal Southeast Water System Improvements	**$14,500,000**
Monroe Water Treatment Plant Expansion	
Intake Facility Pump Upgrade	$ 400,000
Flocculation/Sedimentation Basin (12 mgd)	$ 3,000,000
Filter Building	$ 4,500,000
Air/Water Backwash System	$ 1,200,000
Filter-to-Waste System	$ 500,000
High Service Pump Station	$ 2,000,000
Chemical Feed System Improvements	$ 500,000
Transfer Pump Station Improvements	$ 400,000
Electrical Substation Upgrade (Plant and Intake)	$ 1,000,000
Sitework	$ 600,000
Miscellaneous	$ 1,900,000
Subtotal Monroe Water Treatment Plant Expansion	**$16,000,000**
Subtotal Probable Construction Cost	**$30,500,000**
Contingencies (20%)	$ 6,100,000
Total Probable Construction Cost	**$36,600,000**
Engineering and Construction Administration	$ 7,300,000
Land and Easement Acquisition	$ 400,000
Total Probable Project Cost for Alternative A	**$44,300,000**
UV Disinfection Alternative	$ 4,400,000

[1] All costs are based on January 2007 price levels.

APPENDIX

Table A-2
Opinion of Probable Project Cost for Option to Alternative A
Expand Monroe WTP from 24 mgd to 30 mgd

Item	Cost[1]
Southeast Water System Improvements	
Pump Station (12 mgd expandable to 24 mgd)	$ 3,500,000
Ground Storage Tank (2 MG)	$ 1,600,000
Transmission Mains (44,000 LF)	$ 9,400,000
Subtotal Southeast Water System Improvements	**$14,500,000**
Monroe Water Treatment Plant Expansion	
Intake Facility Pump Upgrade	$ 300,000
Flocculation/Sedimentation Basin (12 mgd)	$ 3,000,000
Filter Building	$ 3,000,000
Air/Water Backwash System	$ 1,000,000
Filter-to-Waste System	$ 400,000
High Service Pump Station	$ 1,000,000
Chemical Feed System Improvements	$ 500,000
Transfer Pump Station Improvements	$ 300,000
Electrical Substation Upgrade (Plant and Intake)	$ 1,000,000
Sitework	$ 500,000
Miscellaneous	$ 1,500,000
Subtotal Monroe Water Treatment Plant Expansion	**$12,500,000**
Subtotal Probable Construction Cost	**$27,000,000**
Contingencies (20%)	$ 5,400,000
Total Probable Construction Cost	**$32,400,000**
Engineering and Construction Administration	$ 5,700,000
Land and Easement Acquisition	$ 400,000
Total Probable Project Cost for Option to Alternative A	**$38,500,000**
UV Disinfection Alternative	$ 3,600,000

[1] All costs are based on January 2007 price levels.

APPENDIX

Table A-3 Opinion of Probable Project Cost for Alternative B New 12 mgd WTP Adjacent to Dillman WWTP	
Item	**Cost**[1]
New WTP, Intake Facility and Water Mains	
Intake Facility	$ 9,500,000
Flocculation/Sedimentation Basins	$ 3,200,000
Membrane Treatment Facility	$ 8,200,000
Chemical Feed and Storage Facility	$ 2,500,000
High Service Pump Station	$ 4,700,000
Administrative Facilities	$ 600,000
Laboratory	$ 400,000
Finished Water Storage	$ 1,900,000
Residuals Pump Station	$ 600,000
Site Work	$ 2,500,000
Engine Generator	$ 600,000
Miscellaneous	$ 3,200,000
Raw and Finished Water Mains (45,000 LF)	$13,000,000
Subtotal New WTP, Intake Facility and Water Mains	**$50,900,000**
Contingencies (20%)	$10,200,000
Total Probable Construction Cost	**$61,100,000**
Engineering and Construction Administration	$ 9,200,000
Land and Easement Acquisition	$ 900,000
Total Probable Project Cost for Alternative B	**$71,200,000**
UV Disinfection Alternative (Retrofit Monroe WTP)	$ 4,100,000

[1] All costs are based on January 2007 price levels.

APPENDIX

Table A-4
Opinion of Probable Project Cost for Alternative C
New 12 mgd North Water Treatment Plant Using Membrane Filtration

Item	Cost[1]
New WTP, Collector Well and Water Mains	
Collector Well	$ 3,800,000
Membrane Treatment Facility (14 mgd)	$ 9,000,000
Reverse Osmosis Membrane Facility (7.7 mgd)	$12,500,000
Chemical Feed and Storage Facility	$ 2,500,000
High Service Pump Station	$ 4,700,000
Administrative Facilities	$ 600,000
Laboratory	$ 400,000
Finished Water Storage	$ 1,900,000
Residuals Pump Station	$ 600,000
Site Work	$ 2,500,000
Engine Generator	$ 600,000
Miscellaneous	$ 3,200,000
Raw and Finished Water Mains (85,000 LF)	$20,800,000
Subtotal New WTP, Collector Well and Water Mains	**$63,100,000**
Contingencies (20%)	$12,600,000
Total Probable Construction Cost	**$75,700,000**
Engineering and Construction Administration	$11,400,000
Land and Easement Acquisition	$ 1,100,000
Collector Well and RO Pilot Studies	$ 400,000
Total Probable Project Cost for Alternative C	**$88,600,000**
UV Disinfection Alternative (Retrofit Monroe WTP)	$ 4,100,000

[1] All costs are based on January 2007 price levels.

Table A-5 Opinion of Probable Project Cost for Option to Alternative C New 12 mgd North Water Treatment Plant Using Gravity Media Filtration	
Item	**Cost[1]**
New WTP, Collector Well and Water Mains	
Collector Well	$ 3,800,000
Filter Building	$ 4,500,000
Reverse Osmosis Membrane Facility (7.7 mgd)	$12,500,000
Chemical Feed and Storage Facility	$ 2,500,000
High Service Pump Station	$ 4,700,000
Administrative Facilities	$ 600,000
Laboratory	$ 400,000
Finished Water Storage	$ 1,900,000
Residuals Pump Station	$ 600,000
Site Work	$ 2,500,000
Engine Generator	$ 600,000
Miscellaneous	$ 3,200,000
Raw and Finished Water Mains (85,000 LF)	$20,800,000
Subtotal New WTP, Collector Well and Water Mains	**$58,600,000**
Contingencies (20%)	$11,700,000
Total Probable Construction Cost	**$70,300,000**
Engineering and Construction Administration	$10,600,000
Land and Easement Acquisition	$ 1,100,000
Collector Well and RO Pilot Studies	$ 400,000
Total Probable Project Cost for Option to Alternative C	**$82,400,000**
UV Disinfection Alternative (Retrofit Monroe WTP)	$ 4,100,000

[1] All costs are based on January 2007 price levels.